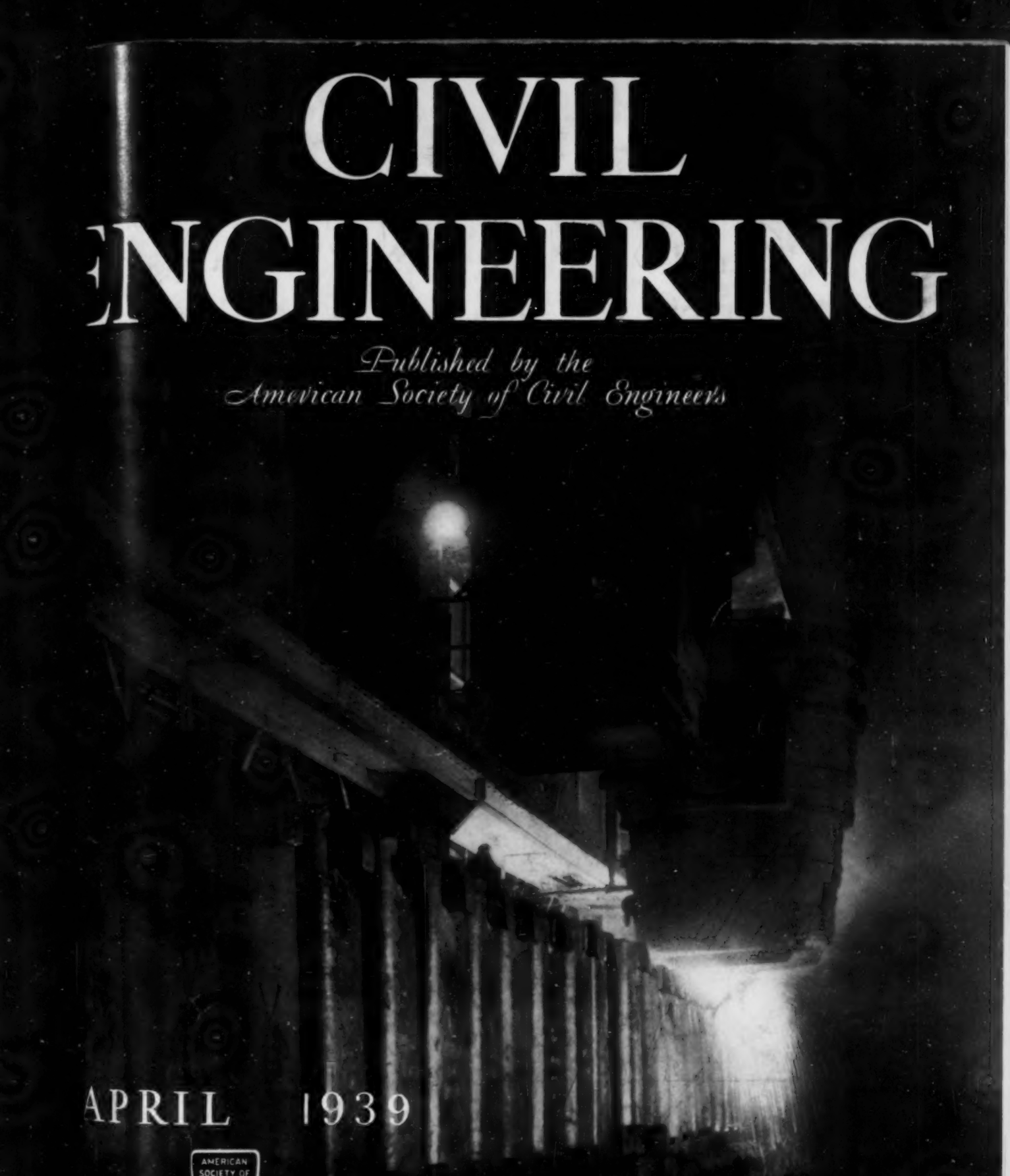
CIVIL ENGINEERING

Published by the American Society of Civil Engineers



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Volume 9

Number 4

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Among Our Writers

CHARLES F. SCOTT (Ohio State University, 1885) was with the Westinghouse Electric and Manufacturing Co. for 23 years, in various engineering capacities and was then professor of electrical engineering at Yale for 22 years. He is a past president of the American Institute of Electrical Engineers and of the Society for the Promotion of Engineering Education.

WILLIAM J. COX studied engineering at Washington and Lee University and subsequently at Yale. He was on the engineering faculty of the latter school for 10 years, leaving in 1938 to become highway commissioner of Connecticut. Earlier he was engaged in building construction and was traffic engineer for the National Bureau of Casualty and Surety Underwriters.

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RICHARD STEPHENS spent 15 years on the preliminary investigations and construction of the Colorado River Aqueduct. He was chief draftsman on mapping, location studies, and estimates of costs for 6 years, and during the last 4 years was office engineer of the field headquarters office. He is now engineer for the American Section, International Boundary Commission, United States and Mexico.

O. H. AMMANN was graduated in 1902 from the Swiss Federal Polytechnic Institute in Zurich. As principal assistant to Gustav Lindenthal, early in the century, he had a part in the design of the famous Hell Gate and Sciotoville bridges. In 1925 he became chief engineer of bridges for the Port of New York Authority. Later he was made chief engineer, and in 1937 director of engineering, for that organization.

HOWARD F. PECKWORTH (Princeton, 1926) had 7 years of experience on subway and underpinning construction in New York City. Following this he was field engineer on the construction of Tygart River Reservoir Dam, resident engineer for the city of Birmingham, Ala., on the construction of Inland Dam, and is now on the design staff of Pacific Constructors, Inc., at Shasta Dam.

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VOLUME 9 NUMBER 4

April 1939

Entered as second class matter September 23, 1930, at the Post Office at Easton, Pa., under the Act of August 24, 1912, and accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918.

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Printed in the U. S. A.

CIVIL ENGINEERING

Published Monthly by the

AMERICAN SOCIETY OF CIVIL ENGINEERS
(Founded November 5, 1852)

PUBLICATION OFFICE: 20TH AND NORTHAMPTON STREETS, EASTON, PA.

EDITORIAL AND ADVERTISING DEPARTMENTS:
33 WEST 39TH STREET, NEW YORK

This Issue Contains

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SUBSCRIPTION RATES

Price, 50 cents a copy; $5.00 a year in advance; $4.00 a year to members and to libraries; and $2.50 a year to members of Student Chapters. Canadian postage 75 cents and foreign postage $1.50 additional.

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IN SUB-FREEZING WEATHER

—OVER 10 YEARS AGO

IN sub-freezing weather, winter of 1928-29, Pennsylvania State Highway Department widened and resurfaced "Bottleneck" Highway, on west bank of the Susquehanna River near Harrisburg. Detour was impracticable, as photo (above) suggests.

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Something to Think About

A Series of Reflective Comments Sponsored by the Committee on Publications

What Is Engineering Experience?

Nation-Wide Study Yields Significant Answers for the Young Aspirant

By CHARLES F. SCOTT

PAST-PRESIDENT AND HONORARY MEMBER, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; PRESIDENT, NATIONAL COUNCIL OF STATE BOARDS OF ENGINEERING EXAMINERS

"I DON'T understand why your board refuses to grant me a license as a professional engineer," said a young applicant to the secretary of a state registration board. "Your requirements are a diploma and four years of experience. I have a diploma and five years' experience, but you turn me down. Why?"

The reply opened his eyes: "You have been doing routine work which has not added to your professional development," it said. "Your experience is not 'satisfactory to the board.' "

Wanted—A Clarification.~Arbitrary as this reply may appear, the secretary was fully justified in making it, because the phrase "satisfactory to the board" is part of the wording of the law. If, therefore, so definite—or indefinite—a phrase is to be found in the law, is it not fitting that the registration boards should undertake an interpretation?

It is a fair question, then: What kind of experience is considered to be "satisfactory to the board?" The National Council of State Boards of Engineering Examiners has been studying this question. Some of the findings of its Committee on Qualifying Experience reported at the Council's October 1938 meeting by the author as chairman, are most illuminating.

When the young man who looks forward to an engineering career seeks professional recognition, his experience record will be scrutinized by the membership committee of an engineering society and by a registration board. Their attitude, as found in our studies and as substantiated by views of members of state boards in some forty states, contains much that may be helpful to the applicant. For his benefit, significant portions of the report are here presented.

An Important Test.~ The experience period following graduation is a vital factor in the career of the individual engineer and in registration procedures. To the recent graduate it provides the opportunity for practice in using his knowledge and training, thus laying the foundation for a future career.

To the engineering registration board the reaction of the applicant to the test of experience indicates whether the man has the qualities the professional engineer should have. It indicates his intellectual habits and attitudes; his methods of thinking and doing; his facility in combining theory and practice; his ability to handle new problems, to visualize, and to plan; his capability to develop, as shown by the use he has made of opportunities for self-development. From the record of what he has done and how he has done it the board has the best basis for projecting his performance curve into the future, as an indication of his competency to practice professional engineering.

Required by Model Law.~State engineering registration laws are usually based upon the Model Law sponsored originally by the American Society of Civil Engineers and later perfected through the joint efforts of a number of the national engineering bodies. According to the Model Law, "the practice of professional engineering. . . includes any professional service. . . wherein the public welfare or the safeguarding of life, health, or property is concerned or involved, when such professional services require the application of engineering principles and data." It defines a professional engineer as ". . . a person who is qualified by reason of his knowledge of mathematics, the physical sciences, and the principles of engineering, acquired by professional education and practical experience, to engage in the practice of professional engineering." Hence the qualification involves the combination of knowledge and experience.

Normally, according to the Model Law, the requirements for registration are an acceptable diploma and a "specific record of an additional four years or more of experience in engineering work of a character satisfactory to the board, and indicating that the applicant is competent to practice professional engineering." If there is no diploma, a longer experience is required.

"Four years or more" implies that the length of the period is to be adequate for acquiring the experience. Since this is given as a minimum, it should be deemed sufficient only in exceptional cases where the experience has been unusually broad in scope, progressively better in character, and notably high in average and final level.

A mention of "character of experience" implies that some kinds of experience are not satisfactory; for ex-

ample, routine performance which does not invoke the application of technical knowledge and which does not contribute to development of qualities that indicate competency to practice professional engineering. Character means quality, not mere quantity of experience measured in time (though a minimum is fixed) or in jobs; and the quality must indicate competency.

Basic Differences.—Broadly, the character of experience considered satisfactory is that which indicates competency to practice professional engineering, and the "ability to do." The following items are pertinent:

The school of experience should be a laboratory for the application of principles to the solving of problems. Knowledge and experience should interact and produce something far beyond the arithmetical sum of textbook information and the doing of routine tasks.

On the same job one engineer may exercise judgment in directing the work, while another may simply follow plans and specifications to the letter. Again, in design, one may use judgment in choice of standards while another may make slavish use of them.

It is too much to expect that qualifying experience can be derived from work which does not require or involve the application of engineering principles and theories; although the work itself may require skill and may be necessary in professional activity, for example, ordinary surveying, drafting, mechanical calculations, routine cost accounting, selling, or contracting. Acceptable experience must involve the intelligent practical application of the laws of physical science.

Experience should be sufficient in amount so that repetition produces (1) thorough understanding of the principles involved and (2) the development of judgment as to the method of analysis and solution.

Two phases of experience are (1) the actual activities performed and (2) the attitude of the individual and his progressive development in performing them. What he does is of less consequence than how he does it.

The Will to Succeed.—There is bound to be a dividing line between those who are indifferent to development and those who are bent on achieving against all obstacles. Thus professional engineering may develop on the basis of higher standards. A progressive advancement in ability to apply engineering data and principles should indicate that the applicant is capable of taking charge of some branch of engineering work. He should recognize his limitations as well as his ability, and should decline to accept an obligation that he knows he is not qualified to fulfill.

A board should secure details of an applicant's duties and responsibilities by asking such questions as these: What did he do? What engineering data or principles did he apply? What engineering judgment and discretion did he exercise? What was the scope and importance of the project? What ability to devise and to plan did he evince? What is the evidence of his progressive responsibility? What initiative and originality and courage, and what personal force for overcoming difficulties has he shown? What progress has he made by reading and study, membership in an engineering society, correspondence-school or night-school courses?

Results, Not Titles.—Obviously, a board cannot rely on titles—they may be very deceptive. Jobs, positions, and accomplishments are significant only as regards the qualities essential to the professional engineer that they produce.

Practical experience is thus defined in Handbook No. 36 of the New York State Board of Examiners of Professional Engineers:

"Practical experience in professional engineering work to be considered to be of a grade and character satisfactory to the Board of Examiners shall be such as to require the intensive application of engineering principles in the practical solution of engineering problems. This work shall predicate a knowledge of engineering mathematics, physical and applied sciences, properties of materials, and the fundamental principles of engineering design. It shall be broad in scope and of such nature as to develop and mature the applicant's engineering knowledge and judgment."

Other Traits Also.—In general, registrants who possess administrative ability are eligible for the higher ranks in their profession. Such men have valuable characteristics for becoming "competent to practice professional engineering." Administrative ability is therefore a desirable though not an essential quality; it may be given consideration in estimating experience as qualifying for "professional engineering" practice.

Professional engineering (as defined in the Model Law) includes ". . . evaluation, planning. . . in connection with any public or private utilities . . . works or projects, wherein the public welfare, or the safeguarding of life, health, or property is concerned." It seems reasonable, then, to expect more than mere physical competency.

Economic justification and social utility are within the larger engineering perspective. Ability to take this larger view, to coordinate many engineering elements in a single project, to adjust it to the environment outside the technical elements, by looking beyond engineering efficiency to social utility and public welfare, this is a quality of our outstanding engineers—a quality to be developed through the years. But, if the young man already has normal knowledge and experience and in addition gives promise of a larger outlook on engineering and life, the board enjoys a double assurance that it is making a wise selection.

Registration Ideal Advances.—Engineering registration in theory and practice is a pioneering effort. Ninety per cent of the 40 states having registration have not had it more than 20 years, and 30 per cent of them have had it less than 4 years. In some states the procedures in licensing are well developed; in others they are just beginning. The National Council seeks to interchange information and unify objectives.

Just as engineering schools and societies, and engineering theory and practice are continually progressing, so must the goals and the procedures in engineering registration. The evaluation of experience cannot be effected through dogmatic definition; discretion must be exercised in each specific case. The applicant should realize that the true function of technical knowledge and qualifying experience is to produce competency to practice professional engineering. This may seem indefinite and intangible. And so it is. It cannot be measured by objective yardsticks; there is a human quality involved in interpreting what is "satisfactory to the board."

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CIVIL ENGINEERING

APRIL 1939

VOLUME 9

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NUMBER 4

Flood and Hurricane Versus the Connecticut Highway Department

By WILLIAM J. COX
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
STATE HIGHWAY COMMISSIONER, STATE HIGHWAY DEPARTMENT, HARTFORD, CONN.

AT NIGHTFALL on September 21, 1938, scarcely a mile of highway in the eastern half of Connecticut was open to unimpeded traffic. The hurricane had just put the finishing touches to what the floods had started a few days earlier, and the Highway Department was confronted with the most serious emergency in its history. Thanks to its organization and the morale of its forces, it met that emergency squarely and efficiently; there was little lost motion, even in the hectic first night that found the field forces separated from central control and without adequate tools or equipment. Six months later, the work of rehabilitation is still going on—though now, of course, at a more leisurely pace. Mr. Cox here tells the story, beginning with the day of the storm; and adds to the interest of his narrative with comments on the lessons learned from the disaster in bridge design and roadside development.

ON September 17, 1938, a disastrous five-day rain commenced in lower New England. It fell, to a total of 12.6 in., on ground that had already received a marked excess of rain in the preceding months. By the evening of September 20, the smaller streams all over Connecticut were roaring out of their banks. Dams and bridges had begun to go out, and roads were beginning to wash badly over large areas. During September 20 and 21, on the state highway system, there were destroyed or seriously damaged 15 bridges of more than 20-ft span and 35 shorter bridges. The effect on the state highway system is indicated in Fig. 1, which shows the main routes radiating east from Hartford and the points at which they were blocked.

This was the state of affairs when the hurricane struck without warning in mid-afternoon of September 21. Within two hours traffic movement had been further complicated by 40,000 trees fallen across the state highways in the central and eastern portions of the state, and a still larger number across town roads and city streets. The shore, also, had been swept by a tidal wave which penetrated inland hundreds of feet, carrying houses, boats, and even some large ships. In Connecticut the property damage was almost certainly in excess of $50,000,000.

A very serious effect of the hurricane was the disruption of all forms of communication. Quite possibly there was not a single mile of highway in the eastern half of the state open to unimpeded travel. Railroad transportation on important routes was at a standstill. Trees in falling had silenced more than 100,000 of the 300,000 telephones in the state. In some large areas all lines were down. Electric power had failed. Even some radio stations were quiet, and a large fraction of the receiving sets in the state were useless.

To complicate the situation still further, as the hurricane swirled off to the north and the smaller streams began to subside, the larger rivers continued to rise. On the following day the bridge over the Connecticut River at Hartford was closed by high water. Because of this (and the loss of smaller bridges) the two-mile trip from Hartford to East Hartford suddenly jumped to eighty miles. The Highway Department was confronted with the most serious emergency it had experienced in the 44 years of its history.

Hartford Times

AT HAWK'S NEST, OLD LYME, COTTAGES WERE SWEPT INLAND AND PILED ON THE ROAD A THOUSAND FEET FROM THE SHORE

Raymond C. Lewis in Circle Magazine

THE BOSTON POST ROAD, AT MADISON, ON SEPTEMBER 22, 1938
Fallen Trees Have Been Trimmed to Open One Lane

When the hurricane struck, practically all the regular field forces of the Department had been engaged for 24 continuous hours on bridge or roadway repairs. Nevertheless as darkness fell on September 21, these forces, though to a large extent separated from central control by the disruption of communications, went into high gear splendidly and almost automatically, and with a spirit and determination worthy of the very highest praise. The approximately 1,700 men already at work on state roads were augmented within a very few hours by 500 additional, and the next day, 2,500 men were working. This rapid expansion in the face of communication difficulties was possible because of the wide discretion given the 11 roadway maintenance supervisors and four roadside maintenance overseers to employ additional men immediately in emergencies. These men were hired from lists furnished by the State Employment Service and kept on file in the supervisors' offices.

SCENES ALONG CONNECTICUT HIGHWAYS AFTER THE FLOODS AND HURRICANE

Left: At Knollwood Beach, Old Saybrook, 3,000 Ft of Shore Highway Protected by Concrete Cribbing Was Completely Destroyed. Right: Near Norfolk, Concrete Slabs Were Undermined by What Is Ordinarily a Small Brook

As the wind subsided, the immediate need, of course, was the removal of the blockading trees. This was started actually before the wind died away, and continued with great vigor right through the night and the next day. By that time the highway forces, assisted somewhat by CCC and WPA workers, and in some few instances by town and city forces, had reopened practically the entire state highway system, at least for one-way traffic, so far as fallen timber and similar obstructions were concerned.

For the most part this opening of the roads was accomplished by hand labor and the use of trucks. Through the night of September 21 state highway workers were using 1,100 axes and 274 cross-cut saws, together with 242 trucks and one or more two-way snow plows. In addition, three mobile cranes, four shovels, and one bulldozer, rented from contractors, were busy. This rented equipment was considerably augmented the following day, and was used most effectively. Practically all Highway Department trucks are equipped with searchlights, and these proved very valuable.

The removal of trees was accomplished in accordance with available equipment and local circumstances. For the most part, the branches were chopped or sawed off and were dragged from the roadway by trucks, to provide a one-way passage. Where the equipment was available, cranes proved of great worth, simply picking up whole trees and shifting them to the roadside. The two-way snow plow showed itself of particular value. It pushed the smaller trees bodily to one side, and where a large tree lay across the road, a single saw cut through the center of the tree permitted pushing the top and butt to either side with one passage of the plow. The bulldozer was similarly used and was very satisfactory.

The procedure followed in tree removal was first to open one-way travel on the more important roads. Next, one-way travel on the less important roads was accomplished. Crews then turned to the task of opening the full width of the roads.

Adequately equipping the expanded highway forces with small tools, and finding supplies of lanterns to mark obstructions on the roads, presented some difficulties. About a 10 per cent excess of hand tools is stocked in the maintenance garages, with another surplus stock in the central stores depot located in the center of the state. The local stocks were frequently inadequate for emergency needs, and communication was too greatly interrupted to make it possible for such supplies as were in the central depot to be made quickly available.

FIG. 1. LIMITS OF TRAVEL ON MAIN ROUTES EASTERLY FROM HARTFORD DUE TO BRIDGE FAILURES, SEPTEMBER 21, 1938

EXPEDITING THE PURCHASE OF SUPPLIES

While the hurricane was still in progress, the Purchases Coordinator of the Department set a force of clerks to work making up schedules of small tool and equipment purchases which would probably be needed. At the same time he secured authorization from the Director of Purchases of the Finance Department to allow direct purchasing in the emergency. Before the hurricane was over, orders for saws had been placed in Philadelphia and orders for rope and other supplies in New York, and during the night these items were trucked in over the roads in the western part of the state, which were little affected by the storm. In some districts where tool supplies were inadequate and communication with other districts was broken, the stocks of local hardware stores were purchased for the department. During the night following the disaster there was some lack and confusion of tools, but within a very brief time this was straightened out.

In the hours immediately following the hurricane, all forces—roadway, landscape, highway boundaries, bridge maintenance, and traffic control—pitched into the job of getting the roads reopened. As soon as the most essential parts of this work had been done, however, the various divisions returned to their more normal duties.

The work of cleaning fallen timber and other debris from the roadsides was quickly taken over by the Bureau of Roadside Development. With the pavements reopened to travel, the most pressing part of the clean-up work was the removal of trees which had fallen against houses or were otherwise so placed as to constitute a menace. This work was effectively accomplished in some places by cranes which traveled down the roads lifting trees from their lodging places. Elsewhere the work was done with hand

tools. These situations were cared for with remarkably little damage to the houses.

The next problem to present itself was removal of the rapidly drying branches which in places were constituting a fire hazard. This was soon started as a state sponsored WPA project. To the general clean-up of roadsides, including removal of stumps, the WPA has allocated $500,000, the Highway Department providing the necessary trucks and drivers, and hand tools.

In this clean-up of roadside areas, the sequence of operations has been first to remove and burn the most inflammable debris. Heavier limbs and logs have then been sawed into lengths suitable for handling, and disposed of by hauling to dumps where they were turned over to the towns to be converted into firewood for relief purposes. The final step, much of which still remains to be done, is the digging up of stumps and refilling of holes. For this work, winches and 15,000-lb cranes, mounted on trucks, have been very valuable.

Replanting of the roadsides will be commenced on Arbor Day, April 8, when 1,200 young trees will be set out as first replacements for the 40,000 destroyed. The total cost of removal of fallen timber, but not including tree replacement, is estimated at $710,000.

VALUE OF SLOPE PROTECTION EVIDENT

The other repair activity of the landscape forces—care of slope damage—is estimated to cost only $12,000. A survey of the various slopes throughout the state in which subsurface drainage, where needed, had been installed and intercepting berm ditches, strip sodding, and other erosion-control measures had been used, shows that all but a surprisingly small amount of this work successfully withstood the storm.

An important lesson from the storm is that the utmost care must be used in locating all future plantings.

FAILURE OF THE UNIONVILLE BRIDGE OVER THE FARMINGTON RIVER WAS DUE TO COLLAPSE OF THE CENTER PIER

Many of the trees lost were so close to the pavement that proper development of root systems had been prevented, or root systems had been mutilated in past highway widening operations. In replanting, care will be taken so to locate the trees that not only will they constitute no traffic hazard but also that they will thrive, sending down root systems adequate to resist high winds.

As soon as the pavement had been freed of trunks and boughs, roadway maintenance forces began replacing washed-out road beds and road surfaces. Considering the severity of the storm, there was less of this than might have been anticipated. Where routes along the shore caught the full force of the waves, complete destruction of some lengths of road occurred. These will be rebuilt by contract during the coming spring. Inland the most serious washout occurred on Route U. S. 44, where 13,000 cu yd of fill had to be placed.

Where the road was undercut from the side, failure, of course, occurred quite irrespective of the pavement.

118th Photographic Section, Air Corps, Conn. National Guard

OCCUM-VERSAILLES HIGHWAY BRIDGE ON SEPTEMBER 22
Note the Channel Cut by River Back of the Far Abutment

However, in situations where water flowed down the road, or across the road, the oiled shoulders that have been a feature of Connecticut road maintenance for many years demonstrated their worth. Unquestionably these shoulders prevented many thousand dollars worth of road erosion. The greater part of state road destruction occurred adjacent to bridges where the approaches were lower than the bridge and washed out, frequently saving the bridge structure. The total cost of state road replacement is expected to amount to about $325,000.

MUCH BRIDGE DAMAGE TRACEABLE TO DAM FAILURES

The heaviest loss to the Highway Department was in bridges, of which, as already stated, 50 were lost or very seriously damaged. These bridges varied in length from 3 ft to 250 ft, three of them being more than 100 ft.

It was on a single small river system that much the greater part of the bridge damage occurred (Fig. 1), and a very large part of this is attributable to the failure of a number of dams. The Shetucket Valley in eastern Connecticut many years ago was intensively developed as a textile manufacturing area, using power generated from a multitude of small dams. In this flood, dams on the headwaters near the Massachusetts line started going out. As the storage released by upstream dams struck those lower down, the latter also failed, adding their sudden increment of waters to the torrent. The Shetucket River is formed by the confluence of the Hop River, the Willimantic River, and the Natchaug River. No dams failed on the Hop River and the maximum flow was only 34 times the average annual flow. On the Willimantic River, however, two dams failed, giving a maximum flood flow ratio of 97 to one. On the Natchaug River system, four dams failed, giving a flood flow ratio of 98 to one.

An accompanying photograph shows a typical failure of this sort—the destruction of the Occum-Versailles Bridge, consequent upon the failure of the power dam of the city of Norwich. Here the stone dam remained intact, with 8 ft of water over the spillway; but the spillway was incapable of receiving the entire flow and the dam washed out around both ends. The raging waters then washed out both approaches to the bridge 100 yd

Hartford Times

AT NORTH WINDHAM, APPROACHES ON BOTH SIDES OF TWO BRIDGES WERE WASHED OUT, BUT NEITHER BRIDGE WAS DAMAGED

below the dam, and the bridge itself failed when the far abutment and the center pier collapsed.

While the Roadside and Maintenance bureaus were carrying out the work previously described, the Bureau of Construction and Engineering was equally busy. Starting the day after the hurricane, engineers were sent out over all the roads in the flood stricken areas with orders to locate all points of traffic interruption, make hurried surveys of the amount and kind of damage, ascertain the best possible detours, and report all this information to the central office at Hartford. Even before that, authorization had been received from the Governor to depart from usual contract procedures and to enter into verbal contracts on a cost-plus basis, using standard equipment rental and labor rates, supplemented by certain additional meal and other allowances to cover the emergency. The day following the hurricane, work was actively under way on this basis. About 12 bridges were quickly repaired or temporary bridges built by contractors at costs that were entirely reasonable. During the same time an equal number of bridges were repaired or temporary bridges built by the bridge maintenance forces of the Department. In this way the most urgent situations were satisfactorily met. Only the smaller bridges, of course, were dealt with as just described. Temporary bridges were located, as far as possible, so as not to interfere with subsequent permanent construction.

Where practical detours made the rebuilding of bridges less urgent, temporary construction was not resorted to. Instead plans for permanent structures were drawn as rapidly as possible, and approximate estimates of quantities were prepared. On these estimates, lettings were held with only three days allowed to contractors for the submission of bids. These proposals were not advertised, but notices were sent to all contractors. The repairs and reconstructions handled in this way were all relatively simple ones. The proposals met with a satisfactory number of bids; prices, though higher than normal, were for the most part very fair; and by October a large volume of permanent reconstruction work was actively under way.

The larger bridges were redesigned at a somewhat more leisurely rate, and in a number of instances are being built with the aid of federal funds. The Highway Department had pending, at the time of the floods, an application for a PWA grant for bridge construction. Following the floods, the Department was allowed to submit a revised application, substituting damaged or destroyed bridges for others which, while in need of replacement, could be maintained in service. This grant, in amount of $1,033,191, was made on November 15, and is assisting tremendously in the reconstruction program. In all, the cost of replacing or repairing flood-lost or flood-damaged bridges is estimated at $1,200,000.

From the longer view, several lessons about bridges were learned from the flood. The first, perhaps, is that adequate supervision over the design, construction, and maintenance of dams is essential to the safety of bridges in a state highway system. No method in use today would have indicated the need for waterways sufficient to carry the floods which resulted from successive failures of dams. Adequate legislation to cover this matter is now before the Connecticut General Assembly.

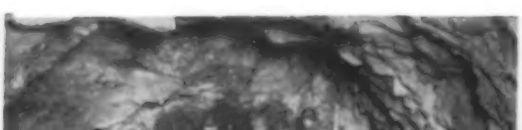
A second lesson concerns the unpredictability of floods. In 1936 there were floods in Connecticut which surpassed all records for the last hundred years. Yet two years later the 1936 levels were approached or equaled in most of the streams of the state, and were surpassed by 6 or 8 ft in some instances. Meyers' formula for required waterway area (which provides that the drainage area in acres be multiplied by a constant ranging from 1 to 4, depending on the terrain) has been used in Connecticut bridge design for many years. Until two years ago it gave very satisfactory results; however, in the light of recent experiences, a revision of the constants is perhaps called for.

FOUNDATIONS MORE VULNERABLE THAN SUPERSTRUCTURES

A lesson indicated by the 1936 floods and strongly emphasized in 1938 is that the failure of bridges resulted almost entirely from failure of the foundations. Superstructures, though inundated and in some cases subjected to tremendous pressures from accumulated debris, stood very successfully through both floods, provided their foundations held. In the 1938 flood, particularly, we learned to our sorrow the fallacy of too great economy in bridge replacement. We lost excellent and fairly new bridges through having founded them on the old abutments and piers, merely rebuilt and strengthened. Too often such piers had not been carried to an adequate depth, and too often piers that appeared sound externally were revealed to be weak internally. An accompanying photograph shows one span of a two-span bridge over the Farmington River. Both spans were lost when the center pier failed. These trusses were erected about twenty years ago, on a pier which was widened and strengthened at that time, but which we now know should have been completely rebuilt. The Occum-Versailles bridge failed for the same reason.

The value of founding piers and abutments on piles, even when not needed from a bearing standpoint, was also demonstrated. In the case of one bridge on the Natchaug River, the foundation was scoured out from 6 to 8 ft below the bottom of footings which were supported on timber piles. No serious damage was done to the structure and repairs are now being made at a very small fraction of the cost of a new bridge. The great value of driving steel sheeting and leaving it in place around footings and abutments was also indicated.

In some cases, where an adequate waterway can be provided only at prohibitive cost, the expedient of leaving approaches at a lower elevation than the bridge structure, and placing the structure on solid foundations which will not be disturbed even though the approaches are destroyed, may be considered sound practice. The last photograph in this article shows an old and a new bridge, over a small river and a race respectively, both of which stood intact although the approaches were completely washed away. The cost of replacing the approaches in this and other cases was far less than that of replacing the structures would have been.



space. Platforms were used on the job, most of the mucking was done by

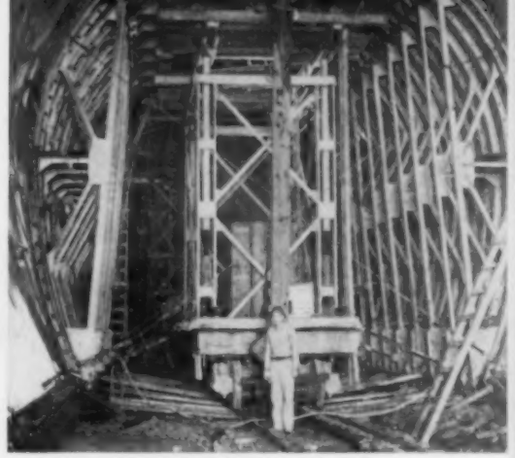
Hard Rock Tunneling

Second of a Series on Modern Construction Tools and Practice

By J. L. BURKHOLDER, M. AM. SOC. C.E.

and RICHARD STEPHENS, ASSOC. M. AM. SOC. C.E.

FORMERLY, RESPECTIVELY, ASSISTANT GENERAL MANAGER, AND OFFICE ENGINEER FOR FIELD HEADQUARTERS, METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA; NOW, RESPECTIVELY, SENIOR ENGINEER AND ENGINEER, INTERNATIONAL BOUNDARY COMMISSION, UNITED STATES AND MEXICO



FORMS AND JUMBO FOR PLACING CONCRETE IN DIVERSION TUNNELS AT PARKER DAM

THE twenty-nine tunnels of the Colorado River Aqueduct, totaling 92.09 miles in length, afford excellent criteria of modern tunnel construction. Built in less than six years under one management and with similar methods and equipment, they present an unusual opportunity for comparing results and for forming conclusions as to the relative economy of comparable methods.

Rock formations penetrated by these tunnels may be broadly grouped in order of their prevalence as (1) granitic and dioritic; (2) metamorphic, consisting principally of mica schist and gneisses; (3) tertiary sediments consisting of medium, hard, red-brown sandstone conglomerate and breccias; (4) partially consolidated quaternary gravels; and (5) compacted alluvium, consisting of sand and sand clay with some "nigger-heads" and boulders.

The tertiary sediments required very little support. All other formations required support varying from 25 to 100 per cent of the length. The gravels and other alluvial materials required support throughout, but were usually coherent enough to permit excavating without spiling or breast-boarding.

Because of difficulties with heavy flows of water, cost and progress records for the San Jacinto and Valverde tunnels are not comparable to the others and are here omitted in such comparisons. Methods employed in driving these two tunnels were described by Mr. Burkholder in CIVIL ENGINEERING for September 1935.

Prior to the beginning of any aqueduct work, the Metropolitan Water District decided to build and operate the necessary construction utilities—power transmission lines, surfaced highways, water lines, and a telephone system. This plan eliminated hazards inherent in desert construction work and thus reduced the bid prices. Charges made for these utilities were $1\frac{1}{4}$ cents per kwhr for power and 15 cents per 100 cu ft for water.

Tunnel construction was started January 1, 1933, and by February 2, 1934, contracts were awarded which resulted in the construction of 47.41 miles of tunnel by 13 nationally known construction firms. The remaining 44.38 miles were built by two District construction organizations. Excavation was carried on from 59 headings, of which 16 were reached from eight grade adits; 12 through six vertical shafts; 5 from three inclined adits; and 26 from portals in access cuts. With the exception of San Jacinto Tunnel, excavation and lining of all tunnels was completed by February 1937, 50 months after construction started. It is anticipated that San Jacinto will be ready for the delivery of water in September 1939.

All these tunnels are horseshoe shaped, 15 ft 3 in. and 16 ft 0 in. in finished diameter.

The precedent set at Boulder Dam of constructing diversion tunnels by the full face method was followed for aqueduct tunnels throughout the job. Because of poor rock structure it was necessary at times temporarily to substitute the top heading and bench method or the top center drift method. The only exception to the full face method was the Whitewater tunnels driven through compacted alluvium. Here the contractor elected to use the heading and bench method. In three other instances tunnels penetrating similar alluvial material were excavated by the full face method with greater progress.

To economize on labor and equipment, the full face "alternating" method was used in a few instances where two headings were being excavated from an adit. In this method the mucking crews and drilling crews stagger their work so that mucking is proceeding in one heading and drilling in the other. Apparently good results were attained in uniform rock which required no support. While a considerable saving in the size of crew was effected by use of this method, equipment could not be transferred with economy over distances greater than about a half mile. Experience with the alternating method showed that there was a great sacrifice in progress, indicating increased driving cost.

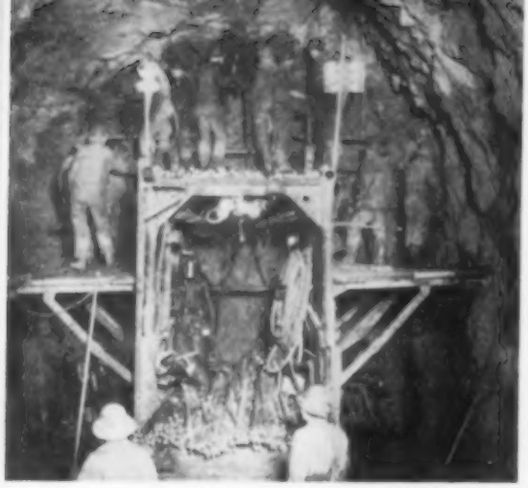
In the full face method of driving, the entire tunnel face is drilled each round from a carriage on which drifter drills are mounted. The typical round required about 45 holes, drilled to a depth of 7.5 ft. The average time required for the drilling cycle, including setting up, drilling, and moving out, was 2.6 hours.

In supported section the normal round was 4 to 6 ft, being regulated to the requirement for spacing of supports. In firm rock, rounds of from 8 to 12 ft were employed. Long rounds generally proved unsatisfactory because the ground broke in large blocks, which could not be handled by the mucking machine and required subsequent plugging and shooting.

The automatic-feed, pneumatic-type machine drill almost completely replaced the screw-feed drill on this work. It was especially advantageous with the inexperienced labor employed at the start of the job because it maintained constant pressure on the bit, thus permitting maximum drilling speed.

Drill carriages consisted of welded pipe framework about 22 ft long, 6 ft wide, and 8 ft high, mounted on 36-in. gage car trucks. Folding platforms on each side and a deck on top provided working

MANY experienced tunnel men hold the opinion that hard rock tunnel construction can be planned either for maximum progress or for maximum economy, but not for both. Experience in tunneling on the Colorado River Aqueduct refutes this belief. With the present greater use of mechanical equipment, say the authors of the accompanying paper, rapid progress and low cost go hand in hand. Their facts and figures are drawn from the construction records of 92 miles of aqueduct tunnels, and cover all important phases of the work.



DRILL JUMBO IN OPERATION

space. Platforms were usually raised and lowered pneumatically. Bars and columns clamped at the end of the carriage provided support for the swiveled drill mountings so that holes could be directed at any desired location or angle. The pipe frame served as a manifold for the water and air supply so that it was necessary to make only two connections to the supply lines to place the unit in operation. In addition to being used for drilling, the carriage facilitated the erection of supports and trimming when such work was done coincidental with driving.

For blasting, 40 and 60 per cent gelatin powder in $1^1/_4$ by 12-in. cartridges was used. The average powder consumption was 2.7 lb per cu yd of solid rock, although some rock required as much as 7 lb. It was detonated electrically from a 440-v circuit used exclusively for this purpose. The average time required for loading, blasting, and clearing the tunnel of fumes was 0.8 hour. Safety measures taken in the use of powder included protection of firing circuits by three locked switches, the use of safety primers (as explained by T. W. Osgood, Assoc. M. Am. Soc. C.E., safety engineer, in CIVIL ENGINEERING for January 1935), and the removal of all electrical circuits from the face before blasting. Lighting of the face during loading was accomplished by flood lights mounted on a tripod and operated from a storage-battery locomotive stationed 75 ft from the face.

Typical ventilating plants employed blowers of either the positive displacement type or the constant-pressure centrifugal type. They were generally designed to deliver 6,000 cu ft per min at each heading through 22-in. metal pipe supported on the sides of the tunnel. After blasting the blower was reversed and run in the exhaust position for 20 to 30 min to remove the accumulated gases.

The early installations of ventilating pipe were generally unsatisfactory owing to loss of air at the joints. The pipe was of 14-gage metal, in 30-ft sections, with slip joints. As the length of tunnels increased, this loss reduced the ventilation of the heading so that it became necessary to weld the joints. With this improvement, the plants gave satisfactory ventilation to headings 20,000 ft distant.

Although five crawler-type, electrically operated shovels were used on the job, most of the mucking was done by 60 conveyer loaders. The shovels were especially built for tunneling, and their $1^1/_4$-cu yd dippers were well adapted to the handling of blocky material. They were operated at the side of the tunnel, and because of the limited working space very careful swinging was necessary, especially in supported ground. The conveyer loaders worked from the permanent center tunnel track, and track construction was simplified where they were used.

Because mucking machines cannot be kept digging continuously, owing to the necessity of switching the car serving the machine, tunnel men are continually striving to improve the switching devices to reduce lost time. Of the many types of such devices tried out in the course of the work, the California switch proved the most successful because of its simplicity, low first cost, and saving in track construction. As perfected on this job, it consisted of a section of double track with frogs and switch points at each end, welded on flat steel cross-members to form a rigid unit which was superimposed on the single center tunnel track. Tapered rail section at each end permitted the easy passage of car trucks. Rollers mounted on camshafts were built into the switch, and the throwing of levers caused the rollers to contact the tunnel track to facilitate moving. Kept close to the heading at all times, one side of the switch stored the empty cars and the other side accumulated the loaded cars. Switching was accomplished either with a locomotive or with a small air hoist and cable mounted on the mucker. With this device, lost time at the mucker can be kept as low as one minute per car.

Other types of switching devices developed and used on the job were described by F. E. Weymouth, M. Am. Soc. C.E., in CIVIL ENGINEERING for May 1934.

The underground motive power generally used was storage-battery locomotives of from 5 to 12-ton capacity with the 8-ton size predominating. Trolley locomotives were used in five tunnels, but as the trolley line could not be carried to the heading, these locomotives were gener-

TABLE I. COLORADO RIVER AQUEDUCT TUNNELS (15 FT 2 IN. AND 16 FT 0 IN. IN FINISHED DIAMETER)

NAME OF TUNNEL	LENGTH IN FT	ACCESS	CLASSIFICATION	PER CENT SUPPORTED	PROGRESS PER SHIFT	MAN-HOURS PER LIN FT	AVE. CREW PER SHIFT
Colorado River	5,842	Portal	Rock, dry	4.3	9.5	26.5	31.4
Copper Basin Nos. 1 & 2	12,273	Portal & 330′ adit	Rock, dry	2.4	7.5	28.7	26.9
Whipple Mountain	32,238	Adit 924′	Rock, dry	18.7	7.8	27.2	26.6
Iron Mountain, east portion	23,645	Shaft 160′	Rock, seepage	51.7	6.1	41.2	31.5
Iron Mountain, west portion	16,208	Portal	Alluvium rock, seepage	60.0	7.6	30.5	29.0
Coxcomb	17,795	Portal	Rock, dry	50.2	7.9	31.5	31.1
East Eagle	9,440	Portal	Rock, dry	74.4	7.0	30.2	26.5
West Eagle, east portion	15,845	Adit 1982′	Rock, seepage	77.5	6.5	31.4	25.5
West Eagle, west portion	10,649	Portal	Rock, seepage	61.1	6.4	37.1	29.5
Hayfield No. 1	9,734	Adit 300′	Rock, dry	98.9	5.7	31.8	22.5
Hayfield No. 2	5,435	Portal	Rock, dry	89.7	6.2	28.8	22.5
Cottonwood	20,105	Portals	Rock, dry	100.0	7.6	30.0	28.2
Mecca Pass, Nos. 1, 2, & 3	5,940	Portals	Rock, dry	100.0	6.3	25.9	20.5
East Coachella Tunnel:							
Yellow Camp	21,572	Adit 686′	Rock, dry	56.3	7.1	27.9	24.6
Fargo Camp	25,361	Adit 891′	Rock, dry	54.9	6.3	32.6	25.5
Berdoo Camp	29,101	Adit 2042′	Rock, dry	33.2	7.6	28.9	27.5
Pushawalla Camp	20,671	Adit 2935′	Rock, dry	82.5	7.0	29.3	25.7
Thousand Palms No. 1	16,058	Portal	Rock, dry	83.9	6.7	31.3	26.1
Thousand Palms No. 2	3,838	Portal	Rock, dry	69.3	5.4	30.1	20.4
Wide Canyon No. 1	14,305	Portal	Rock, dry	80.0	5.8	34.0	24.6
Wide Canyon No. 2	848	Portal	Rock, dry	100.0	3.8	44.2	21.2
Seven Palms	16,730	Portals	Rock, dry	71.1	7.8	26.2	25.5
Long Canyon	15,305	Portal	Rock, dry	85.1	8.7	24.2	26.4
Blind Canyon	6,836	Portal	Rock, dry	99.4	8.2	24.3	25.0
Morongo No. 1	5,725	Portal	Rock, dry	98.4	7.7	25.0	24.2
Morongo No. 2	1,892	Portal	Rock, dry	100.0	14.8	17.4	32.0
Whitewater No. 1	2,060	Portal	Alluvium, dry	100.0	7.3	32.5	29.6
Whitewater No. 2	8,172	Portal	Alluvium, dry	100.0	8.8	26.9	29.6
Bernasconi*	6,220	Portal	Rock, seepage	21.1	5.3	35.2	23.3
Total dry tunnels	379,383 or 71.85 miles			62.0	7.04	30.2	26.6
San Jacinto	68,843	†	Rock, heavy inflows	50.0	3.9		
Valverde*	38,015	‡	Alluvium rock, wet	60.4	3.4		
Total wet tunnels	106,858 or 20.24 miles			55.0	3.72		

* 15 ft 3 in. in finished diameter. † Inclined adits 238 ft, 5,664 ft; shafts 246 ft, 796 ft; cross-cut 925 ft. ‡ Inclined adit 391 ft; shafts 64 ft, 204 ft, 192 ft.

ally equipped with batteries for operation in this region. In lieu of this "combination" type, one tunnel employed trolley locomotives that carried a reel of cable so that power could be supplied from the trolley line as the locomotive advanced beyond its end. Gasoline locomotives were used on most of the jobs for outside haulage.

The locomotive batteries gave outstanding service—from 10 to 14 hours of haulage use without recharging, when new. Some are still in use at San Jacinto after over five years of continuous service.

Steel cars of $3^1/_2$ to 6-cu yd capacity, equipped with roller or ball bearing journals, were used for muck haulage. They were either side dump or mine type. Automatic couplers were used in some instances but the bar-and-pin type predominated. Used with a special safety link to secure greater separation of cars, this type gave a satisfactory safety performance.

The 30-in. gage tunnel haulage tracks of 40-lb rail were built to uniform grade and straight alinement to permit rapid transportation. Trains of from 8 to 12 loaded cars were hauled. Automatic or hand-operated block signals and telephones installed at critical points served to speed up haulage with safety.

BATTERY LOCOMOTIVE AND MUCK CARS IN COACHELLA TUNNELS

Three types of temporary support were used to meet varying rock conditions—timber lagged steel, metal lagged steel, and timber. Gunite was applied extensively to the arch and side walls of unsupported tunnels to prevent air slacking and spalling. Applied as a coating of 1 in. or less thick, its early use generally saved the time and expense of erecting supports.

Because much of the ground required only light support, experiments were made by the District to develop a relatively inexpensive and quickly erected type. This led to the adoption of a two-segment steel rib which could be shaped to tunnel section by rolling from standard steel 4-in., 6-in., and 8-in. I-sections, thus making available a type of support which by varying the spacing would fit any condition except very heavy ground. Timber collar braces and steel rods were used to bind the sets together. Timber lagging was installed back of the ribs as required, usually being placed as open cribbing so that concrete could be forced through openings to the rock walls. This type of support was an important factor in increasing progress and reducing cost. Prior to placing concrete lining, this support was used to replace timber sets which had settled. In such cases the necessity for tunnel enlargement was frequently avoided.

Metal-lagged steel supports, consisting of arch ribs supported on wall beams and columns and lagged with corrugated pressed-steel liner plates bolted to the ribs, were used extensively at the beginning of the job, especially in tunnels through compacted alluvium. Costs for both material and labor of erection ran high, and as a result this type was gradually displaced by the timber-lagged steel type.

Timber supports were the usual 5 or 7-segment sets supported by plumb-posts in dimensional sizes of 10 by 10 in., 12 by 12 in., and 16 by 16 in. Wall plates were used occasionally with the top heading and bench method to support soft ground. Ultimately the 10 by 10-in. timber support was supplanted by the steel ribs, but steel support was generally found not adaptable for use in heavy ground.

Comparative costs per foot for erection and material for the various types of support were as follows: steel ribs with timber lagging, $14.50; timber, $21.70; steel ribs with metal lagging, $38.10; gunite, $2.40.

Experience in the dry tunnels showed that as good progress can be made in ground requiring continuous light support as in unsupported ground. The outstanding example of this was the Morongo No. 2 Tunnel, supported continuously by timber-lagged steel ribs on 5-ft centers, where the driving progress averaged 14.8 ft per shift (the aqueduct record) throughout its 1,892-ft length. The formation penetrated was compacted alluvium with some "nigger-heads," requiring drilling and blasting by the standard full-face method.

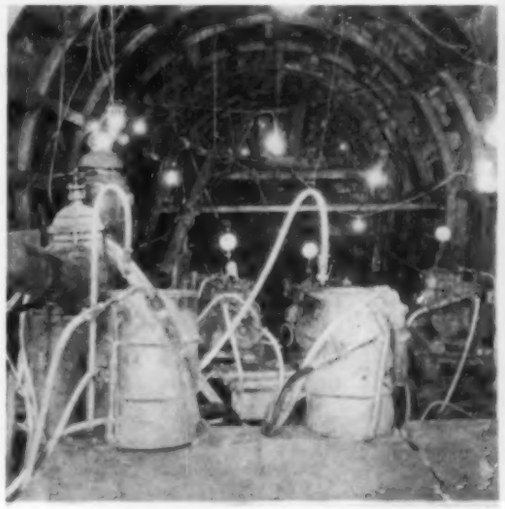
Concrete material for lining was batched at plants located near the tunnel entrances, where the weighed dry materials were placed in specially designed cars for transportation into the tunnels. Water was added at the mixer and the concrete was pumped or shot behind the forms through a single pipe. Both the continuous-pour method and the bulkhead method were employed for arch lining. The former utilized 200 ft of telescoping steel arch forms, which were moved ahead in 20-ft sections as the work advanced. The latter required 60 to 140 ft of non-telescoping steel forms, which were moved ahead after the concrete had set. Both methods gave good results but fewer cracks occurred in lining placed by the bulkhead method. Better progress was secured by continuous placing.

Most of the 1,554,234 cu yd of concrete placed in tunnel lining, exclusive of San Jacinto, was placed with pumps. Placing with pumps is still progressing in San Jacinto. Their use is believed to have effected an economy in cement because they handled a dryer concrete.

The concrete pump was adapted to tunnel lining by the District's design of a placing unit mounted on self-propelled car trucks which comprised a batch unloading hoist, a mixer, an agitator, a pump, and the necessary discharge pipe. Such units have a mixer capacity of 1 cu yd and a placing capacity of 25 cu yd per hr. Six of these units placed 712,394 cu yd of arch concrete at an average rate of 187 cu yd per 8-hr shift. Four pump units having a 2-cu yd mixer and a placing capacity of 40 cu yd per hr were also employed. This type placed 203,245 cu yd at an average of 278 cu yd per shift.

A number of different types of air-placing units were used with good results, placing 434,434 cu yd of concrete at an average of 145 cu yd per shift. The record rates of placing were 311 cu yd per shift for air and 312 cu yd per shift for pumps.

Invert concrete was generally placed after the arch concrete, and with the arch lining unit. A weighted screed, supported on the 6-in. curb projecting from the base of the arch sidewalls, was used to strike the surface. Mechanical vibrators were employed to work the concrete under the



SET-UP FOR HIGH-PRESSURE GROUTING IN SAN JACINTO TUNNEL

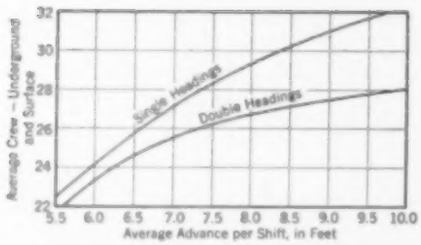


FIG. 1. RELATION BETWEEN AVERAGE CREW AND AVERAGE ADVANCE PER SHIFT FOR 71.85 MILES OF 16-FT DIAMETER DRY TUNNELS

screed, and a smooth hard surface was secured by steel troweling. Invert placing in dry tunnels was done at an average of 100 cu yd, or 268 lin ft, per shift.

Of the total concrete placed in tunnel lining, 20 per cent went to fill overbroken areas outside of the pay line. The average pay quantity was 2.98 cu yd per lin ft, and the average placed was 3.72 cu yd per lin ft. This work required an average of 11.46 man-hours, 63.4 kwhr of electricity, and 460 gal of water per lin ft of tunnel.

In the San Jacinto and Valverde tunnels extensive pressure grouting was done to shut off water that might build up objectionable pressures on the concrete lining, and to increase the strength of the lining. This operation was accomplished in several stages. The voids back of the lining were first grouted at low pressures and later sealed with high pressures.

Grout was also used to fill the voids disclosed by a systematic drilling of test holes in the arch. No pressure was employed in this case, and sand was usually added to the grout mixture to lower the cost.

Typical construction costs for the dry tunnels are represented by the District's force-account construction of the 33.74 miles in the Coachella Tunnels. The total cost per linear foot was $100.35, of which $70.20 was for excavation and support, and $30.15 was for lining, including cement. The average cost of excavation was $3.60 per cu yd, and the average cost of concrete placed in lining was $6.68 per cu yd. These are total construction costs and include a plant and equipment depreciation of $1.05 per cu yd for excavation, and $0.40 per cu yd for lining, as well as cost of tunnel access, superintendence and accounts, and engineering and administration.

The installed cost of plant and equipment for dry tunnel excavation (exclusive of camps and utilities) was proportional to the length of tunnel driven from each surface plant. The following table represents average costs (1933 basis) for both single and double headings for dry tunnels of various lengths:

LENGTH IN FEET	SINGLE HEADING	DOUBLE HEADING
5,000	$ 87,000	.....
7,500	104,000	.....
10,000	130,000	$175,000
12,500	170,000	190,000
15,000	215,000	202,000
17,500	245,000	215,000
20,000	.....	235,000
25,000	.....	300,000
30,000	.....	370,000

These costs represent the total outlay for equipment plus the cost of labor and material for installation. They do not reflect the salvage value. It will be noted that single headings were equipped at less cost than double headings for lengths of 14,000 ft or less, and conversely.

The records for driving all main aqueduct tunnels show an average progress of 5.89 ft per 8-hr shift. For dry tunnels the average is 7.04, and for difficult wet tunnels 3.71 ft. Outstanding monthly advances of 1,101 ft and 1,084 ft were made in Thousand Palms No. 1 and in Copper Basin No. 2 tunnels. The high daily advances of 54 ft and 55 ft were made in Seven Palms and Whipple tunnels, respectively. Table I shows the pertinent progress and man-hour data for all tunnels. This outstanding progress was made possible by the following expedients: (1) Selection of men of exceptional ability to fill the key positions; (2) adoption of the full face method of driving and the development of improved plant units to take advantage of this method; (3) general use of standby mechanical units such as mucking machines, machine drills, locomotives, and concrete placing units; (4) development and use of more quickly erected supports (timber-lagged steel); (5) emphasis placed on progress by job managers. The progress records on all tunnels were distributed to the workmen in the District's bi-weekly publication. This fostered a spirit of friendly rivalry between crews.

While the costs and progress expressed as averages for the entire job are believed to be exceptional, the driving of 27 tunnels from 44 headings under similar conditions and through comparable formations gave a wide range of individual records. These records have been studied to find out whether the tunnels having the best progress records also have the best cost records.

For the individual headings the average size of crew has been plotted against the average advance per shift for both single and double headings (Fig. 1). The curves are the average experience for all dry tunnel construction and indicate the following:

1. Progress per shift varied as the size of crew varied, more men being required for greater progress.
2. For the same progress larger crews were required for single-heading than for double-heading operations.

The jobs that made the better rates of progress utilized larger crews and paid out greater sums for labor. In order to determine whether these increased labor costs were justified, progress per shift has been plotted in Fig. 2 against actual cost of excavation, exclusive of cost of support. This graph shows that the tunnels which made the best average progress were driven at the lowest cost. It indicates that an increase in progress of 1 ft per shift had a value of $7.20 in excess of the additional cost for the increased crew. Each mile of tunnel driven at the increased rate would represent a saving of $38,000. As a means of increasing progress, a portion of this sum could have been expended for additional equipment or bonuses, if necessary.

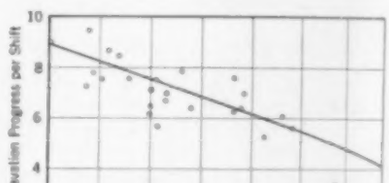
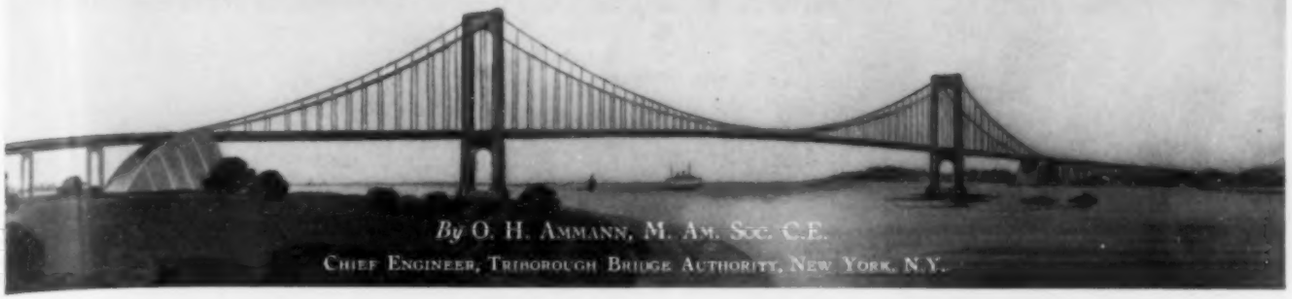


FIG. 2. RELATION BETWEEN EXCAVATION PROGRESS AND COST FOR 71.85 MILES OF 16-FT DIAMETER DRY TUNNELS

Tunnel driving progress is not a commodity that can always be purchased, for ground conditions to a large degree determine costs. But it is equally true that tunnels are frequently either over or under equipped, or over or under manned, and it is believed that the cost-progress diagram indicates a trend of the relationship between these factors which supports the general statement that high progress and low cost go hand in hand. In tunnel work where good progress can normally be made it is usually possible to step up the average advance by plant improvements and by fostering the competitive spirit common to all good workmen.

The tunnels described in this article were constructed by the Metropolitan Water District of Southern California, of which Frank E. Weymouth, Hon. M. Am. Soc. C.E., is general manager and chief engineer, and Julian Hinds, M. Am. Soc. C.E., is assistant chief engineer.

Planning and Design of Bronx-Whitestone Bridge



By O. H. Ammann, M. Am. Soc. C.E.
Chief Engineer, Triborough Bridge Authority, New York, N.Y.

THE Bronx-Whitestone Bridge across the East River in New York, now nearing completion, adds one more to an already imposing list of great spans erected within the last ten years. Like all structures of unusual proportions, it presents its peculiar problems and materializes in its design certain ideas and developments to a more far-reaching degree than its predecessors.

Among its uncommon features are the application to such a great suspension span of a flexible stiffening system in the form of solid plate girders, and the design of the towers as rigid frames without any diagonal cross-bracing either above or below the floor. Both features contribute to the graceful appearance and structural simplicity of this type of bridge.

The simplicity and economy of the design are further reflected in the anchorages and adjacent approach viaducts, which are reduced to the minimum as to materials required for strength and stability, and are devoid of extraneous architectural embellishments. This structural simplicity has in no small degree contributed to the unprecedented speed in the construction of the bridge.

As a self-liquidating bridge project it deserves recognition because of the liberal inclusion of approach highways, planned not merely as modern traffic arteries, but as parkways, 250 to 400 ft wide, which with the bridge form another link, about five miles long, in the metropolitan parkway system.

The project owes its inception in 1935, a year before the opening of the Triborough Bridge, and its rapid consummation to the vision and resourceful efforts of Robert Moses, chairman of the Triborough Bridge Authority, who realized that the bridge would form an essential link in the arterial highway system and a valuable approach to the New York World's Fair, which was then being planned at Flushing Meadows.

Involving an expenditure of $18,000,000, the project was financed by the Triborough Bridge Authority in April 1937. This was a logical step, because the Triborough and Whitestone bridges are to some extent competitive—about 26 per cent of the Triborough Bridge traffic may be diverted to the Whitestone Bridge. This and other diversions, plus an allowance for new traffic, should bring the volume over the Whitestone Bridge in the first year to at least 6,500,000 vehicles. The combined volume over both the Triborough and the Whitestone bridges should be close to 16,000,000 vehicles. With the same toll rates now in force on the Triborough Bridge—25 cents for passenger cars and from 25 to 75 cents for trucks and buses—and an estimated annual operating charge for the two bridges of $600,000, the net revenue will be more than sufficient to carry interest and sinking fund charges. Thus both bridges, individually and jointly, will be self-liquidating.

Construction was started in June 1937 and so rapid has been the progress that the bridge is expected to be ready for traffic on April 29, or three months earlier than was originally anticipated.

ANOTHER link in the comprehensive arterial highway system of the New York Metropolitan region will be completed on April 29, 1939, with the opening of the Bronx-Whitestone Bridge. The new structure breaks no records for length of span but it embodies a number of departures in design that emphasize, more strongly perhaps than mere increase in size, the rapid progress that is taking place in the bridge-builder's art.

TYPE OF BRIDGE, SPAN ARRANGEMENT, AND TRAFFIC CAPACITY

The East River at the bridge site is about 3,300 ft wide between shore lines and 2,250 ft between pierhead lines established by the War Department. A solid rock bed of Manhattan schist lies at a depth of 100 ft below water level near the Bronx shore, 160 ft below on the Queens side, and at a possibly greater depth near midstream. An overlying layer of glacial drift of varying thickness, and a layer of silt forming the bottom of the river, precluded the placing of pier foundations above the rock.

Under these circumstances it appeared that a single suspension span with towers located close to the pierhead lines was the most suitable solution. The Queens tower and anchorage might have been placed farther out in the river, thus shortening the channel span. This, however, would have resulted in a lopsided arrangement with respect to the river, and its economy would not have been sufficient to outweigh the advantage of a waterway entirely free from obstruction to navigation. Another possible solution, namely two long river spans of the arch or truss type, with a pier about midstream, would have been of questionable economy, because of the great cost of a central pier and the relative cheapness of the suspension type for such a long span.

With the center span fixed at 2,300 ft, the adoption of side spans 735 ft long was essentially a matter of economical relationship to the center span, since no topographical or geological conditions influenced the location of the anchorages. The total length of the bridge proper, including the anchorages, thus became 4,015 ft. A clear height of 135 ft above mean high water at the channel line near the Bronx shore satisfied navigation requirements. The height increases to 150 ft at the center of the span.

The approach viaduct on the Queens side is 1,620 ft in length, and that on the Bronx side is 2,360 ft. Both viaducts consist of continuous plate girder spans on concrete piers.

Preliminary studies made for a four-lane and a six-lane capacity indicated a cost differential of three million dollars. In the expectation that a four-lane structure would have ample reserve capacity for many years, and that when traffic reached the capacity of the bridge, the construction of another crossing in that general vicinity would be-

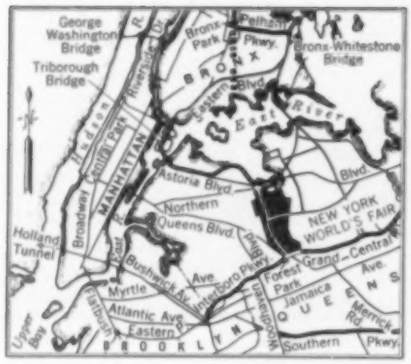


FIG. 1. LOCATION MAP

come justified, the four-lane alternate was adopted.

In the final plans, however, each of the two roadways was made 27 ft 6 in. wide at the bottom and 29 ft 1 in. wide at the top of the curves in order to provide greater traffic flexibility and to take care more effectively of traffic peaks, which on this crossing will occur at times of heavy pleasure automobile traffic (Fig. 2). Experience on the George Washington Bridge, which now has roadways 28 ft 9 in. wide between vertical curbs, has proved that during traffic peaks passenger automobiles travel conveniently in three lanes in one direction. As many as 3,961 cars crossed this bridge in one direction during a peak hour, or 65 per cent more than the maximum number ever recorded on a two-lane roadway in the Holland Tunnel (2,393 cars per hour).

Since the load from six lanes of automobiles is not greater than the average from four lanes of mixed traffic, it was permissible to proportion the structure for a four-lane load. The additional cost by reason of the wider floor was found to be only $250,000.

DESIGN SPECIFICATIONS

With few modifications the design specifications used for the George Washington Bridge (TRANSACTIONS, American Society of Civil Engineers, Vol. 97, 1933) were adopted for the Bronx-Whitestone Bridge.

The actual average dead load of the suspended structure is 10,940 lb per ft of bridge in the center span and 10,780 in the side spans. The weight of each tower is approximately 3,500 tons.

The live load corresponding to four lanes of vehicular traffic was assumed at 3,000 lb per ft of bridge for the design of stiffening girders, cables, towers, and anchorages, and at 8,000 lb for the suspenders.

The wind force from an intensity of 30 lb per sq ft of exposed surface was estimated at 800 lb per ft of bridge acting on the floor, 120 lb on both cables, and 5,500 lb per ft of height on each tower.

A change in temperature of ±55 F was assumed to determine stresses and one of ±75 F to allow for expansion and contraction of the floor.

For the two roadways a light 4½-in. concrete slab encasing longitudinal bulb beams and transverse reinforcing rods was found most suitable and economical. Under the provisions of the contract the American Bridge Company submitted and was permitted to use the so-called I-beam Lok floor, which is similar in design. The slab rests on cross-beams, which in turn rest on the longitudinal stringers that frame into the main floorbeams. The latter are riveted girders 6½ ft deep, located alternately at and midway between the suspenders. They are framed into the main longitudinal girders, which act as stiffening girders, one on each side of the floor in the plane of the cable and suspenders.

The stiffening girders also act as chords of the wind truss and form the outer railings of the footwalks. The diagonals of the wind truss—which, with every second floorbeam, form a K-system—are located in the plane of the bottom flanges of the roadway stringers.

Expansion joints are provided in the roadway at each tower. At the anchorages the floor is fixed longitudinally, but open joints allow it to deflect. The stiffening girders are discontinued at the towers and their ends suspended by short hinged hangers from brackets attached to the towers.

STIFFENING GIRDERS AND WIND TRUSS

It is now well established that long-span suspension bridges for modern highway traffic may have a relatively flexible stiffening system, and that the degree of flexibility has a material effect upon the economy of the design. In this respect the Bronx-Whitestone Bridge marks another radical departure from past theories and practice. Its stiffening girders have greater flexibility in relation to span length than any other suspension bridge built in recent years, except the George Washington Bridge in its present state with only a single unstiffened highway deck. The latter bridge, however, with a present roadway capacity equivalent to that of the Bronx-Whitestone Bridge, has a suspended dead weight per linear foot 2 ½ times greater, a center span 56 per cent longer, and side spans somewhat shorter, all of which factors contribute to the greater rigidity of the unstiffened cables.

It was the aim of the writer, on esthetic as well as structural and economical grounds, to restrict the height of the floor structure to a minimum, to avoid trusses, and to keep the top at such an elevation above the floor as not to obstruct the view of the landscape from passing vehicles. A depth of 11 ft for the stiffening girders was found to be sufficient and to fit best into the floor structure. This is only 1/210 of the length of the center span and 1/70 of the side span.

The flexibility vertically is such that the stiffening girders exert very little restraint upon the deformations of the unstiffened cables, except under heavy local load concentrations. Under a live load covering the center span, and maximum temperature, the unstiffened cables would deflect in the center 9.85 ft, while the stiffened cables deflect 9.72 ft, a reduction of only 1.3 per cent. For a live load covering the central 700 ft, the corresponding values are 10.77 and 9.50 ft, a reduction of 11.8 per cent. The maximum deflection at the quarter point is 9.90 ft without the stiffening girders and 9.27 ft with them—a reduction by the stiffening girders of 6.4 per cent. The function of the stiffening girders is thus reduced principally to stiffening the floor system against excessive local bending of the floor and to acting as chords of the wind truss.

The maximum grade changes from live load and temperature

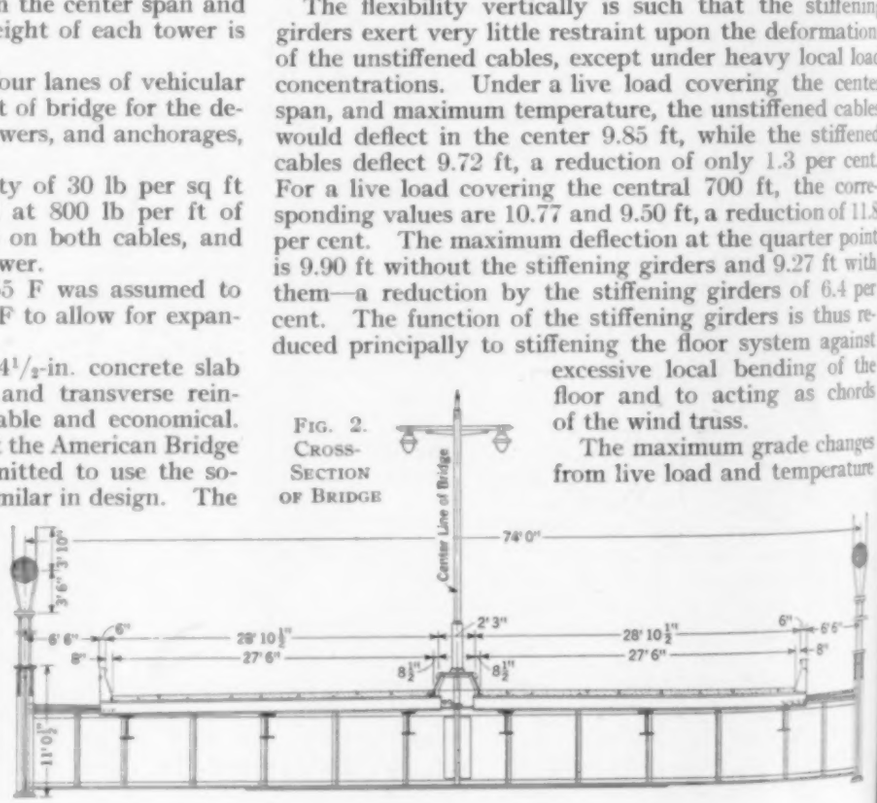


FIG. 2. CROSS-SECTION OF BRIDGE

in the floor occur in the center span at the towers where the normal grade of the roadway is 4 per cent. Low temperature combined with live load could increase the grade by 3 per cent, though under actual conditions the increase will probably never be more than 1 per cent.

The tilting of the floor transversely at the center of the center span due to live load on only one roadway is 6.3 per cent.

For the stiffening girders in the center span, silicon steel was selected as the most economical material. The unit stress for a combination of wind with temperature and one-half live load is 30,800 lb per sq in. in tension and 25,300 lb in compression. The axial stress due to wind is predominant and, in order to make the section effective against buckling, the girder web had to be thickened to $^3/_4$ in. and stiffened by longitudinal angles.

In the side spans the maximum combination of live load, temperature, and one-half wind load causes unit stresses of 25,300 lb in tension and 22,100 lb in compression, for which carbon steel was adequate. Because the axial stress from wind is small, no strengthening of the $^1/_2$-in. web against buckling was required. The weight of both stiffening girders is only 1,540 lb per ft of bridge in the center span and 1,250 lb in the side spans.

The wind truss is hinged at the towers and anchorages. Having a width of 74 ft between stiffening girders, or only $^1/_{21}$ of the center span, it is fairly flexible, with the result that of the 800-lb wind force acting directly on the floor, an average of 300 lb is transmitted to the cables. The lateral deflection of cables and floor at the center of the main span under full wind force is 8.5 ft, or $^1/_{245}$ of the center span. Wind truss diagonals are of carbon steel and weigh on the average only 207 lb per ft of bridge.

CABLES, SUSPENDERS, AND ANCHORAGES

The suspenders and cables, their details and materials, conform to recent practice in the design of large wire cable suspension bridges. The sag of the cables, 200 ft or $^1/_{11.5}$ of the length of the center span, is compatible with good design and graceful appearance. Each of the two cables has a finished diameter of about 22 in. and a net sectional area of wire of 297 sq in.

The maximum stress in the two cables from dead load, live load, and temperature is 50,200,000 lb. A resulting axial unit stress of 84,500 lb per sq in. was permitted. This is 3 per cent higher than allowed in other recently built large bridges, but is justified in view of the uniformity and high average strength and ductility obtained for this cold-drawn wire. The results from about 4,300 specimen tests showed a range of from 226,300 to 242,300, with an average of 233,300 lb per sq in. for strength, an average yield point (defined as the point where elongation in 10 inches is 0.70 per cent) of 177,500 lb per sq in., and an average elongation in 10 in. of 6.6 per cent.

Each suspender consists of the two parts of a prestressed 2-in. wire rope looped over the cable bands. The rope when tested to destruction over a sheave was required to develop a strength of the two parts of 600,000 lb, and the actual strength in three tests ranged between 714,400 and 717,800 lb. The maximum stress in a suspender is 340,000 lb.

Back of the anchorage cable bearings the strands of each cable splay and connect in the usual manner with the anchorage eyebar chains.

Each anchorage presents the appearance of a plain concrete block 110 ft wide, 180 ft long, and 110 ft high

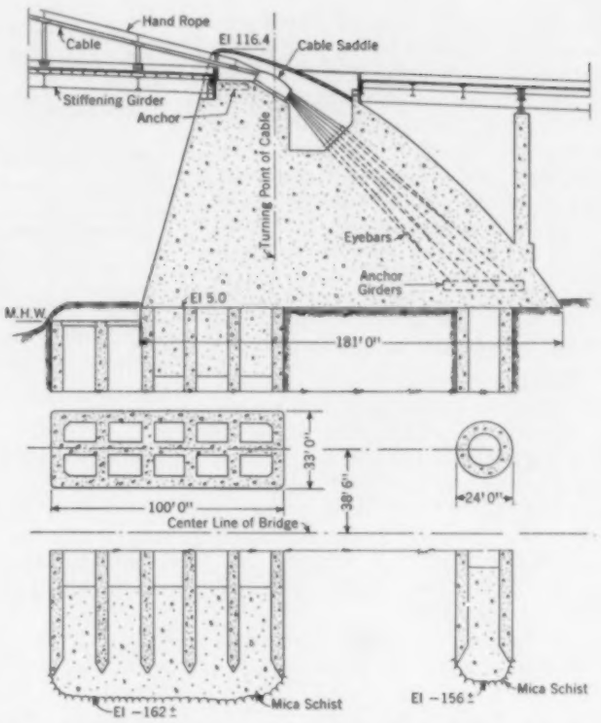


FIG. 3. VERTICAL SECTION THROUGH QUEENS ANCHORAGE, WITH HALF-SECTION THROUGH CAISSONS

(Fig. 3). It is almost triangular in elevation, the rear face being curved to follow roughly the direction of the cables and anchorage chains. There are no architectural embellishments except slanting grooves, indicative of the lines of pressure, which are provided to break the uniformity of the surface. The distribution of concrete is such as to assure stability and permissible stresses and foundation pressures with the minimum amount of material.

In plan the anchorage is U-shaped, the rear half being solid concrete while the front half consists of two side walls, 32 ft thick at the bottom and joined at the front face by a thin curtain wall.

The eyebar chains run diagonally down to the heel of the anchorage block. There they are connected to a set of double-web anchorage girders which, for convenience of erection, are placed horizontally, and rest upon a grillage of beams and girders.

The Bronx anchorage has a concrete base, 15 ft thick, which distributes the pressure to the firm sand and gravel soil only 16 to 21 ft below the surface.

The Queens anchorage, which is the one shown in Fig. 3, rests on four caissons, two rectangular ones under the front part and two circular ones at the rear. The latter take only vertical loads, the horizontal force being resisted by the front caissons. All foundations were carried to solid rock at depths of 156 to 164 ft below mean high water.

The size of the rear caissons was governed by the load condition prior to the taking of stress by the cables. Under this temporary condition the maximum foundation pressure was 44.9 tons per sq ft with buoyancy neglected. Under full cable pull the rear caissons are almost relieved of compression.

The front caissons were located and proportioned so that under full cable pull there would remain a small downward pressure on top of the rear caissons and the foundation pressure at the front of the front caissons would be within the permissible limit, while the com-

pression at the rear of the front caisson on top had to be within the permissible compression of concrete. To meet these conditions with greatest economy, the four dredging wells in the front part of the front caissons were not filled with concrete. The maximum compression at the top of the front caissons is 670 lb per sq in. and the maximum foundation pressure, neglecting buoyancy, is 32.5 tons per sq ft.

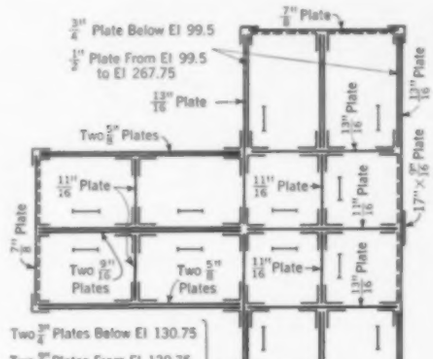


FIG. 4. TYPICAL TOWER-SHAFT SECTION

TOWERS AND THEIR FOUNDATIONS

The towers are elastic frames, very plain in appearance and simple in structural design (see Page of Special Interest in this issue). Each tower consists of two vertical shafts tied together by two deep portals, one at the top, high above the floor, and one immediately below the floor. Transverse diagonal bracing or intermediate struts are avoided. The shafts and portals are of closed box section throughout.

The omission of sway bracing in the tower frame results in greater bending stresses and transverse deflections from wind, and in turn in greater secondary stresses from the vertical loads due to these deflections. However, as designed the tower frames possess great rigidity as is indicated by the relatively small transverse deflection of $5\frac{1}{2}$ in. at the top. The secondary stresses from the vertical loads due to this deflection amount to less than 5 per cent of the total fiber stress.

The towers are 377 ft high from mean high water to top of cable housing. Each tower shaft has a T-shaped section (Fig. 4) which is subdivided by intermediate webs into 12 rectangular cells. The width parallel to the axis of the bridge tapers uniformly from 18 ft at the bottom to 12 ft at the top. Transversely the shaft width is uniformly 16 ft. The shaft sections are stiffened longitudinally by diaphragms from 8 to 13 ft apart.

Each tower shaft rests on a structural steel base which is in fact an extension of the shaft section, spreading the bearing on top of the concrete piers to an area of 25 by 27 ft. Since under certain combinations of forces tension results at the extreme corners of the tower base, the latter is securely anchored to the pier by means of twenty-four 3-in. anchor bolts which engage a steel frame embedded in the concrete.

The portals have a rectangular box section 7 ft wide and 23 ft deep at the center. They are also stiffened by horizontal and vertical diaphragms. The towers are topped by a housing which covers the cable bearings and supports the airway beacons.

The rigid portal at the top made it possible to place the cable bearings excentrically with respect to the axis of the shafts, as seen in the cross-section of the bridge. This was desirable to effect a simple and economical arrangement of the floor structure at the towers. The bending stresses in the shafts resulting from this excentricity are appreciable only near the top, where the bending stresses from the longitudinal deflection of the towers are smallest.

DEFLECTIONS AND STRESSES IN TOWERS

The cables were so adjusted in relation to the towers that under normal temperature and full dead load the towers deflect at the top 3 in. shoreward parallel to the axis of the bridge. Under the most unfavorable combination of live load and temperature they deflect from this normal position 15 in. riverward and $11\frac{1}{2}$ in. shoreward, or from the vertical position 12 in. and $14\frac{1}{2}$ in., respectively.

The maximum combination of axial and bending stresses calls for fairly uniform shaft sections, increasing from 1,637 sq in. at the top to 2,070 sq in. at the base. It was found that with the minimum sections practicable for the adopted dimensions of the tower shafts, carbon steel was adequate throughout. Silicon steel would have involved excess sections.

The maximum axial unit stresses in the tower shafts are about one-half of the maximum extreme fiber stresses and less than two-thirds of the permissible stresses for axial compression. The extreme fiber stresses govern throughout. The maximum stress is 21,100 lb for a combination of dead load, full wind, one-half live load, and one-half temperature.

Each steel tower rests on a pier consisting of two solid concrete pedestals, 34 ft square, extending from 14 ft above mean high water to 10 ft below. The two pedestals are connected by a deep reinforced concrete strut, and each pedestal rests on an open caisson, 38 ft square, with four interior dredging wells which are left open, except for a seal course at the bottom, so as to minimize the foundation pressure. The foundations reached depths of from 144 to 151 ft on the Queens side and from 96 to 98 ft on the Bronx side. The average foundation pressure is 18 tons, and the greatest corner pressure 26 tons per sq ft.

QUANTITIES, CONTRACTORS, AND ENGINEERS

The bridge and approaches contain 22,300 tons of steelwork, exclusive of reinforcement in concrete. Of this quantity, 14,500 tons are structural carbon steel, 3,030 tons silicon steel, 4,370 tons steel wire, and 400 tons steel castings. There are about 200,000 cu yd of concrete in the foundations, piers, and anchorages. The cost of the bridge and approaches, exclusive of property, is approximately $10,000,000.

Construction was carried out under five major contracts by the following contractors: Frederick Snare Corporation (tower and anchorage foundations); Corbetta Construction Company, Inc. (anchorages and approach piers); and American Bridge Company (towers and entire superstructure).

In planning and design of the bridge and approaches the writer was assisted by E. W. Stearns, assistant chief engineer; Allston Dana, engineer of design; and E. W. Bowden, assistant to the chief engineer. Leon S. Moisseiff was consulting engineer on design; Moran, Proctor, and Freeman, consulting engineers on the foundations; and Aymar Embury, architect. Madigan-Hyland, consulting engineers (E. H. Praeger, chief engineer, and Col. H. W. Hudson, engineer of construction), were in charge of the planning of the parkway connections and the construction work for the entire project. Waddell and Hardesty were consulting engineers for the bascule bridge across Flushing River, a part of the project. The inspection of all materials was attended to by the inspection division of the Port of New York Authority in charge of George L. Lucas, engineer of inspection. All the individuals mentioned are Members of the Society.

Field Control of Compacted Earth Fill

General Considerations, and Description of a Simple and Reasonably Accurate Testing Technique

By Howard F. Peckworth

Member American Society of Civil Engineers

Pacific Constructors, Inc., Shasta Dam, Redding, Calif.

The field control procedure described here shows the relationship between characteristics of earth suitability, permeability, shearing value, and density. It also gives a simple, direct, and reasonably accurate method of finding the degree of densification of compacted earth such as is encountered in rolled earth fills, with a field method giving directly the relationship between the density of a given material of known moisture content and the number of passes with a given roller. A copy of the author's original manuscript, of which this is an abridgment, has been filed in the Engineering Societies Library for reference (50 pages of typewritten text, 25 figures, and 23 photographs).

SUITABILITY of the earth to be used in a compacted fill depends on many factors, foremost of which are the nearness and economic feasibility of hauling the earth into place; the workability of the earth after it has been hauled into place; its impermeability or ability to hold back water in the impervious section of the fill; its shearing value or ability to hold its place when saturated; and its freedom from objectionable vegetable matter and minerals soluble in water.

Workability is a function of the water content, the size and shape of individual grains, the size and grading of the individual grains as shown on a grain size accumulation curve, the size of the block into which the earth breaks up when taken from the borrow pit, and the type of soil. Workability will control the type and weight of the rolling equipment, and the rolling equipment to a certain extent will change an unworkable earth into a workable one. The desired degree of compaction can be obtained with fewer passes with a heavy roller than with a lighter roller up to a certain point, but the foot-pounds of work done by a roller depend upon the relationship between the workability of the earth and the weight of the roller. This relationship can only be obtained by field observation and field tests. For instance, an extremely light roller could possibly make an infinite number of passes over a heavy, dry, shaly clay and not give the compaction a heavier roller would; likewise a uniform, fine-grained, plastic clay rolled with an infinitely heavy roller and at the upper limits of moisture content might never be compacted because the roller would merely punch holes in it or churn it back and forth. Thus it is impossible to equate foot-pounds of work to number of passes by a given roller on a given material. In other words, we cannot compute how much energy must be expended to produce a fill that will meet the given density or permeability requirements. The compaction results of a given number of passes by a roller of a given weight on a given material must be measured in the field by accurate field tests.

Placing Fill at Inland Dam, Birmingham, Ala. While the Truck-Dumped Material Is Being Spread, Large Rocks Are Picked Out by Hand

Permeability after saturation is a function of many qualities, some of which are the true cohesion (intermolecular attraction); the apparent cohesion (true cohesion plus capillary rise); the size, shape, and grading of the grains; the temperature that controls viscosity; the compaction, densification, and percentage of air voids; freedom from large rocks; and the percentage of material that will decay or become soluble in water.

The standard expression for rate of percolation through compacted fill is a distance divided by time, while the permeability coefficient is the quantity of water at 60 F in gallons per day flowing through a 1-sq ft area of the fill normal to the direction of flow under a hydraulic gradient of 1. The method of field control should be exact enough to produce a fill having within close limits the predetermined permeability. The possible working limits might vary from zero to 100 gal per sq ft per day, and it is now recognized that the zero limit is almost unattainable, thus changing the problem to that of controlling, limiting, and predicting leakage instead of trying to attain absolute impermeability.

Sheepsfoot Rollers Working in Lanes, Showing Proper Method of Turning at Ends

The shearing value of the earth is dependent on two factors—the cohesion, both true and apparent, and the internal friction. These factors in turn depend on the type of earth used; the size, shape, and grading of the grains; and the degree of compaction and percentage of air voids after compaction. It also depends on the water content and on the past history of the soil—that is, whether it has been subjected to great pressure, weathering, rolling,

HAND TAMPING NEXT TO A CUTOFF WALL

or proximity to pile-driving operations. The angle of internal friction is a purely theoretical angle arrived at by finding the shearing stresses of samples of the same material to which differing amounts of vertical load are applied. The unit shearing force at point of yield is plotted vertically, and the vertically applied unit load is plotted horizontally. An average straight line is drawn between these points and the angle between this line and the horizontal is the angle of internal friction. If the line goes through the zero point, the earth is cohesionless. In cohesive material the line will intersect the vertical at a certain stress, which equals the cohesive value of the material or the unit shearing stress at a vertically applied load of zero. In using the angle of internal friction in calculations for the design of suitable slopes, homogeneity and constant cohesion must be assumed or the embankment slopes must be changed to suit material from different borrow pits.

In applying the results obtained, the differing conditions affecting embankments must be thought of—for instance, conditions of continual submergence; sudden drawdown; continual seepage without submergence; the presence of dried fissures, clay, or excessive cracking at the top of the slope; and the vertical distance from the toe of the slope to bedrock. Also, mature experience and common sense must be freely brought into play along with the mathematical calculations. Going from a material with a cohesive value in excess of 1,000 lb per sq ft and an angle of internal friction in excess of 40 deg, through well-graded clay, stiff clay, soft clay, and almost liquid clay, the cohesive value would drop to below 100 lb per sq ft and the angle of internal friction would approach zero.

DETERMINING MINIMUM DENSITY REQUIREMENTS

After the supplies of earth have been examined for availability and suitability, a laboratory examination should be made to decide on minimum density requirements. The dry weight per cubic foot after compaction is a criterion of density, and the dry weight selected for the finished fill must be a function of the minimum density necessary to satisfy the shearing value determined upon plus a liberal factor of safety (usually from 50 to 100 per cent). It must also satisfy the maximum allowable rate of percolation, plus a liberal factor of safety. But in satisfying both these conditions, it must come within the economic limits of workability and to do this a weight of roller must be determined by experiment that will give the desired dry weight with from 6 to 30 passes. The angles of internal friction and rates of percolation should be determined at different degrees of densification from very loosely packed earth to very densely packed earth, and these tests should be made in a first-class soils laboratory by experienced soil technicians.

As there is an optimum degree of moisture at which the desired compaction can be obtained with a minimum expenditure of energy, field moisture content must be set between limits below which and above which the minimum dry weight cannot be obtained with the equipment and earth at hand. This can be readily determined by making absolute specific gravity tests, drawing the "zero air voids" curve, and comparing it with the dry-weight-moisture-content curve. (A typical zero air voids curve is presented as Fig. 1. It shows the relation between the dry weight per cubic foot and the moisture content of a series of theoretical samples of a given earth containing nothing but earth particles and water. The dry-weight-moisture-content curve, shown in Fig. 2, is an actual curve made by compacting samples of the same earth containing varying amounts of moisture, all samples being compacted with exactly the same amount of work and under identical conditions.)

A comparison of the dry weight per cubic foot obtained in the laboratory (when making the dry-weight-moisture-content curve) with the dry weight per cubic foot obtained in the field (under the roller and with field conditions of moisture) can be made by the following compacted earth density test, which consists of a simple, direct, and reasonably accurate method of getting the weight, volume, and moisture content of a sample of the rolled fill.

TECHNIQUE OF FIELD TEST FOR DENSITY

Remove the top 6 in. of fill material over an area at least 2 ft square and form a perfectly level area by using a shovel, trowel, and carpenter's level. In this area cut out a hole of about 1 cu ft in volume, removing every bit of earth and placing it carefully on a piece of tin or on the pan of a scale. Weigh it carefully after removing stones that will not pass a $\frac{1}{4}$-in. sieve.

The hole can be laid out by cutting with a knife or a trowel in order to get a smooth sharp edge, the remainder being removed with an earth auger or a a post-hole digger. The exact volume of the hole can then be found by placing a box of known volume in the hole and pouring engine oil around the box from a graduated beaker. Experiment will determine the viscosity of the oil to use; in very porous earth, dry sand of known weight per volume can be substituted for the oil. The volume of the stones not passing a $\frac{1}{4}$-in. sieve can be found by dropping them in the oil in the graduated beaker. This volume should then be subtracted from the

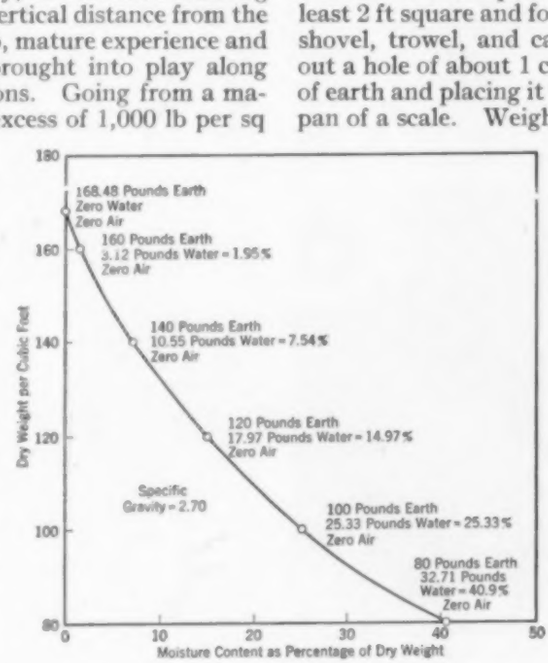


FIG. 1. THE ZERO AIR VOIDS CURVE

volume of the hole. The oil in the hole can be salvaged with a small hand pump.

The care exercised and the precision of the instruments used will determine the accuracy of the results. The moisture content can be readily obtained by drying a sample in a small electric oven at a temperature below the boiling point of water. In the field, samples can be dried on tin pie-plates over an open coal fire, although this must be done with care. By the latter method the dry weight of a cubic foot of the compacted material can be obtained in about ten minutes.

Using this volumetric density test to find the dry weight per cubic foot after each pass with the sheepsfoot roller, and plotting the results graphically with dry weight per cubic foot on the vertical axis and number of passes of the roller on the horizontal, the experimental correlation chart can be drawn (Fig. 3). Naturally a new chart should be drawn for each change in moisture content or in borrow pit material. One inspector with a helper can easily make charts for the placing of 2,000 cu yd of earth per 8-hr shift, and once the charts are drawn it is very easy to predict the density obtained with a given number of passes. The density needed to satisfy the minimum requirements of permeability, consolidation, and angle of internal friction should have been determined previously, of course, by laboratory tests for each different material used.

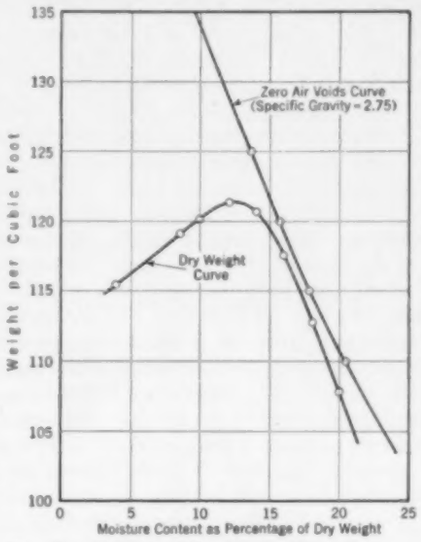


FIG. 2. TYPICAL MOISTURE-CONTENT–DRY-WEIGHT CURVE COMPARED WITH ZERO AIR VOIDS CURVE

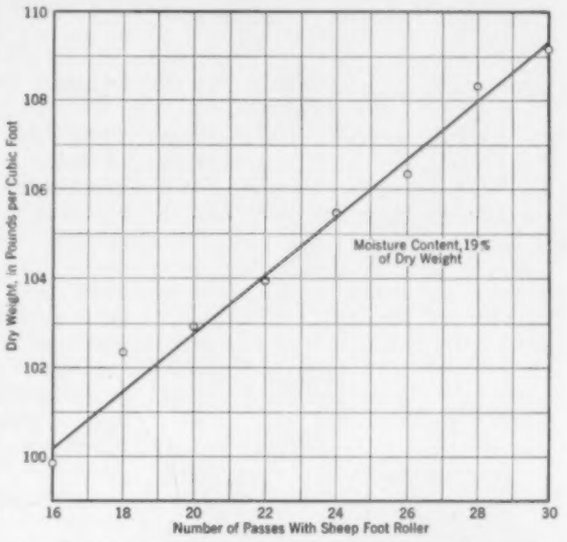


FIG. 3. EXPERIMENTAL CORRELATION CHART, SHOWING RELATION BETWEEN NUMBER OF PASSES OF ROLLER AND WEIGHT OF COMPACTED SOIL

OBJECTIONS TO USE OF PENETRATION NEEDLE

This experimental correlation method of controlled density gives directly the relationship between moisture content, density, and number of passes with the sheepsfoot roller. It can be carried out by the average inspector without the use of expensive equipment, and it gives positive results directly without the necessity of correlating the plasticity. This method has been used in preference to the penetration needle method for the following reasons: (1) Plasticity is not only a function of moisture content but also of grain size and shape; (2) side friction on the needle varies at different degrees of moisture and with different materials even when using a needle of blunt end of larger diameter than the shaft; (3) the personal equation gives non-uniform needle readings; (4) it is almost impossible to obtain truly vertical movement during penetration; (5) the position in which the operator must stand makes accurate measurement of the depth of penetration very difficult, especially when the soil bulges adjacent to the area penetrated; (6) a constant rate of penetration only can be estimated because of the position in which the operator must stand and because the handle and the needle move at different rates of speed; (7) stones are often encountered; (8) material passing a No. 200 sieve often occurs in lumps, thus acting like stones; and (9) earth from borrow pits is seldom homogeneous.

EQUIPMENT AND PREPARATION OF SOIL FOR VOLUMETRIC DENSITY TEST IN FIELD

SUMMARY AND CONCLUSIONS

To recapitulate:

1. Suitability of material for compacted earth fill should be determined only after careful study of the borrow pits, using an ample number of samples and subjecting them to a thorough geological, practical, and laboratory examination.
2. Laboratory findings regarding permeability, consolidation, and angle of internal friction should be translated into density requirements in the field.
3. Density in the field should be measured directly either by the volumetric-density test previously outlined or by some similar method.
4. Density should be correlated with moisture content, number of passes with the roller, and the material being used, so that the contractor can tell by a glance at the experimental correlation chart how many passes he must make to fulfill the requirements of his contract. This chart will also show him immediately why he is required to work within specified moisture limits.

This method was worked out and used by the writer while resident engineer in charge of the placing and testing of a million cubic yards of compacted earth fill in Inland Dam and Ketona Reservoir, built under the direction of A. C. Polk, M. Am. Soc. C.E., executive engineer for the Birmingham (Ala.) Industrial Water Supply Commission, with J. D. Webb, A. C. Decker, M. Am. Soc. C.E., and W. G. Thurlow, M. Am. Soc. C.E., Commissioners.

Engineering Problems in Milk Sanitation

A Relatively New Field for Sanitary Engineers That Offers Many Possibilities

By LESLIE C. FRANK

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TWENTY years ago only one or two state sanitary engineering bureaus were interesting themselves in milk control, and not a single city employed a sanitary engineer in connection with such work. Today the picture is changing. In at least 25 states, milk sanitation work is being done by the bureaus of sanitary engineering, and a similar tendency is beginning to appear in some local health departments. In future, says Mr. Frank, the field may be expected increasingly to require the serious attention of sanitary engineers. In the accompanying article, he describes a variety of engineering problems in milk control, and suggests that instruction in that type of work might well be included in the sanitary engineering curriculum. His full paper, here abridged, was on the Sanitary Engineering Division program at the 1939 Annual Meeting.

UNTIL fairly recently, sanitary engineers have not considered that milk sanitation was a problem with which they should much concern themselves. Conclusive evidence of this may be seen in the past curricula of sanitary engineering courses. Practically none of the graduate sanitary engineers in the field today included a study of milk sanitation in their undergraduate courses.

As time has gone on, however, it has become increasingly apparent that milk sanitation is not exclusively a problem for veterinarians, bacteriologists, and epidemiologists. The conviction has steadily grown that the pasteurization of all market milk supplies, essentially an engineering problem, is a vital necessity. This is because we have learned that no other measure and, in fact, no combination of other measures, gives adequate protection.

Now the use of the pasteurization process at once poses problems regarding the design and operation of pasteurization equipment, and it is at this point that the wisdom of adding sanitary engineers to the milk sanitation staff becomes sharply apparent. However, the function of the sanitary engineer is not limited to the immediate problem of pasteurization. His work really begins at the producing farm.

One of the first items with which he should concern himself is the design of the dairy barn and milk house—the drafting of plans which will insure that there is adequate space to prevent contamination due to overcrowding, adequate light to insure cleanliness morale, adequate ventilation to prevent the absorption of odors and flavors and the drip from condensation on the ceiling, proper construction of floors and walls to promote easy cleaning, and proper arrangement to facilitate the required sequence of operations.

The next item that should receive his attention is the design and construction of dairy farm water supplies—for a contaminated water supply would mean that the slightest relaxation or accident in the bactericidal treatment of milk utensils and equipment washed in the dairy farm water supplies might produce disaster.

In most cases water carriage of excreta is not resorted to on dairy farms. Instead, sanitary privies of the pit type are widely used, and while such privies are relatively simple, their design and construction are within the province of the sanitary engineer. In some cases, too, farms desire to use a water carriage system of excreta disposal and in these cases the sanitary engineer should be called upon to give advice.

The next problem to which the attention of the sanitary engineer is being directed is that of pasteurization plant design. Here again we have the problems of adequate light and ventilation; proper construction of floors, walls, and ceilings; proper drainage; proper lay-out to separate the milk-receiving and utensil-cleaning processes from the pasteurization and subsequent operations, so as to avoid cross-contamination; and proper design and installation of milk receiving, filtration or clarification, pasteurization, cooling, and bottling equipment.

The engineering divisions of several state boards of health have devoted some attention to the drafting of plans for pasteurization plants, and also offer their services to milk distributors who are contemplating the construction or reconstruction of a plant. This calls attention to another and even more recent development. In the 1939 edition of the Public Health Service milk code will appear the requirement that plans for all dairies and milk plants which are hereafter constructed, reconstructed, or extensively altered shall be submitted to the health officer for approval, and the further requirement that in the case of milk plants, signed approval shall be obtained from the state health department. It is reasonable to believe that in future it will be a routine matter for sanitary engineering divisions of state boards of health to be required to pass upon all plans for pasteurization plant construction or reconstruction.

At first thought it might be assumed that water used by pasteurization plants is drawn from approved public supplies and therefore does not require the special attention of the sanitary engineer. However, a number of pasteurization plants are located beyond city limits and have their own independent supplies. In addition, a large number of plants make dual use of both an independent and a public water supply, and frequently have them cross-connected. Therefore each such plant should be studied by the sanitary engineer to determine whether its independent water supply is safe, and whether there is any cross-connection with the public water supply.

PLUMBING DEFECTS COMMON

Pasteurization-plant plumbing constitutes another important sanitary engineering problem. In 1935, W. Scott Johnson, M. Am. Soc. C.E., read a paper on plumbing hazards in pasteurization plants before the Engineering Section of the American Public Health Association. In that paper he described the results of a plumbing survey of six pasteurization plants in St. Louis. He described the finding of 210 separate plumbing defects, involving 28 different kinds of milk-plant equipment and including direct pipe connections between potable water supplies and sewage or contaminated water supplies.

potable water inlets submerged so as to permit back siphonage during intervals of negative head, sewer lines located above pasteurizers or other milk processing equipment, instances of potential aerial pollution, and faulty drinking fountains.

The problem of pasteurization-plant excreta and waste disposal does not often engage the attention of a sanitary engineer, as in the majority of instances such plants are connected with a public sewer. However, some plants are located outside the public sewer districts and in these instances special sewage treatment plants must be designed. In the past the solution of this problem has often been unsatisfactory both because of the composition of dairy wastes and because of their extreme variability in amount and kind during a single 24-hour period.

REQUIREMENTS OF PASTEURIZATION PLANT EQUIPMENT

In the design and operation of regenerators we have a problem that involves an engineering study of relative pressures in various parts of a heat exchange system. A regenerator, as understood by the milk industry, is simply a heat exchanger which is designed to permit the incoming cold raw milk to recapture some of the heat from the outflowing hot pasteurized milk. The regenerator may be either of the "tube-within-a-tube" type or of the plate type; in either case, if leakage develops in the metal separating the raw from the pasteurized milk, and simultaneously the raw milk is under higher pressure than the pasteurized milk, then the raw milk may contaminate the pasteurized milk.

The solution, obviously, is to develop design, installation, and operation specifications to insure that the pasteurized milk side of the regenerator is under higher pressure than the raw milk side whenever there is any raw milk in the regenerator—not only during the routine flow period but also at the beginning of the day's run and during periods of interruption, when the pressure picture may be quite different. Such specifications have been worked out in detail and described in Public Health Reports.

The solution involves not only the proper placing in the flow line of milk pumps and heat transfer medium pumps so as to take proper advantage of the differential between suction and discharge pressures, but also proper elevations for the free milk levels upstream and downstream from the regenerator so that proper relative pressures will obtain during shutdowns (Fig. 1). In addition, in certain designs it is necessary that hot water, chlorine solution, or previously pasteurized milk must, at the beginning of the day's run, be introduced into the pasteurized-milk side of the regenerator before raw milk is admitted to the raw-milk side.

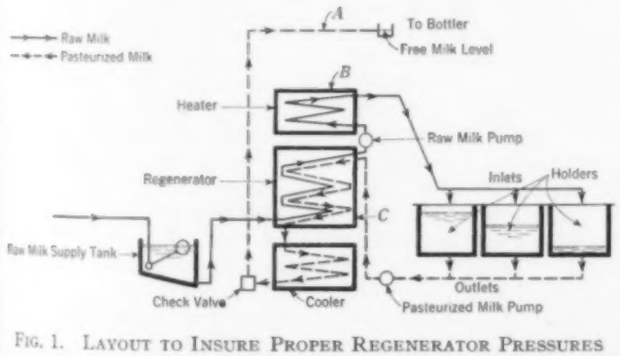

FIG. 1. LAYOUT TO INSURE PROPER REGENERATOR PRESSURES
The Following Points in Design Should Be Noted: (1) Raw-Milk Supply Tank Overflow Is Lower Than Lowest Raw-Milk Point in Regenerator. (2) Raw-Milk Pump Sucks Raw Milk Through Regenerator to Heater and Holders. (3) Pasteurized-Milk Pump Forces Pasteurized Milk Through Regenerator, Cooler, and Check Valve. (4) Point *A* in Pasteurized-Milk Line Is Above Highest Raw-Milk Point *B* by at Least 3 Per Cent of Difference in Elevation Between *B* and Lowest Raw-Milk Regenerator Point *C*, Thus Maintaining Proper Relative Pressures During Shutdowns. (5) Check Valve Prevents Reduction of Pasteurized-Milk Pressures During Shutdowns

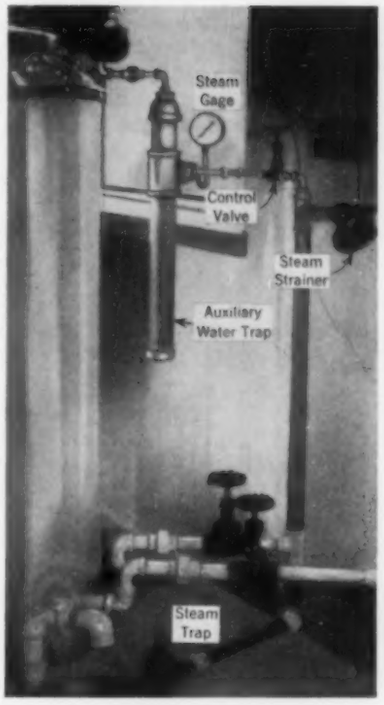

FIG. 2. AIR SPACE HEATER DEVELOPED BY PUBLIC HEALTH SERVICE FOR HEATING AND DISSIPATING FOAM IN MILK VAT

The aspect of milk sanitation which has introduced the most serious sanitary engineering problems is the requirement of the definition of pasteurization that every particle of milk shall be brought to the full pasteurization temperature and held thereat for the full "holding time." Only a few years ago this subject seemed to offer no problem at all. Then it was discovered that the temperature of the milk at the thermometer bulbs might be and frequently was higher than in other parts of the holder—for example, the zone between the face of the outlet valve and the main body of the milk. As a result of this finding, the requirement was inserted in the milk code recommended by the Public Health Service that the design of the holder shall be such that simultaneous temperature differences between various points in the holder will be limited to a tolerance of not over 1 F. Furthermore all outlet valves are required to be of the flush or close-coupled type, that is, so designed as to bring the face of the outlet valve close enough to the main body of the milk in the vat to eliminate the "cold pocket" at the outlet.

It was also discovered that since practically all milk valves were of the metal seat type, and since practically all metal seat valves leak sooner or later, there was real danger that raw milk in the vat would leak out through the outlet valve into the pasteurized milk line before it had been completely pasteurized. So the Public Health Service inserted a requirement in its recommended milk code that all inlet and outlet valves must be of the leak-protector type—that is, so designed as to divert to the outside, by means of leak grooves or otherwise, any leakage which attempted to pass the valve face.

About the same time it was also found that the foam which may be formed on the surface of the milk in a vat is likely to be considerably colder than the main body of the milk, and therefore that means must be developed to heat or dissipate the foam. Our studies developed the fact that while radiant or convection heating of the air above the milk by means of electric or enclosed steam heaters was not very satisfactory, live steam admitted to the air space above the milk tended not only to heat the foam as it was formed but also to dissipate it (Fig. 2).

It was necessary, of course, to design the apparatus so as to prevent the discharge into the milk of either steam-line sediment or a significant amount of steam condensate. Furthermore, since the amount of steam required was very small, it was necessary to increase the sensitivity of the throat of the throttle valve to the maximum by placing a resistance in the line in such manner as to reduce the differential pressure on the two sides of the valve.

FIG. 3. AN AUTOMATIC MILK-FLOW STOP OF THE DIVERSION VALVE TYPE

Automatic pasteurization is rapidly replacing manual pasteurization, particularly in the larger plants. This trend, as might be expected, is introducing a whole series of sanitary engineering problems. In automatic pasteurization, both admission to and discharge from the holder are automatic and unless otherwise prevented will take place even if the milk has not been brought to the proper temperature or held at that temperature for the proper time. Furthermore, since the holding time is automatically controlled, any temperature failure in the holder would require emergency manipulation of the automatic time control, or diversion of the entire supply back to the heater until the temperature failure had been corrected. This, in the case of batch-type holders, would be extremely hazardous because of the quantity of milk that would be required to be repasteurized and the ever-present temptation on the part of the operator to shirk the responsibility in order to save time. In these cases it has been considered fundamentally necessary, in the formulation of the Public Health Service milk code, to surround all automatic pasteurizers with all necessary safeguards to insure that the likelihood of either temperature or holding-time failure will be reduced to the very minimum.

Accordingly the first requirement that has been laid down is that all automatic systems must be provided with thermostatic control of the temperature of the milk entering the holder. Next, since even the best thermostatic control occasionally fails, it was considered highly advisable to include a device which would automatically halt the flow of milk beyond the holder if the thermostat failed or if any temperature drop occurred in the holder. Such a "milk-flow stop" can take either of two forms:

1. An automatic milk-pump stop which will stop the pump motors whenever the milk temperature drops below the pasteurization temperature, and automatically restart the motors whenever the required milk temperature is again reached, or

2. An automatic milk-flow diversion device which will automatically divert the milk away from all downstream points whenever its temperature drops below the required pasteurization temperature, and automatically reestablish forward flow when the milk again reaches the required temperature (Fig. 3).

After careful study a set of specifications for design and installation of milk-flow stops was inserted in the Public Health Service milk code.

There are obviously also special requirements with reference to time control for automatic systems. These include requirements relative to the use of constant-speed motors or limited maximum-speed motors on milk pumps and timing devices, the prevention of inter-pocket flow, the prevention of air or gas accumulation in tubular or equivalent stream-flow holders, and the checking of the holding time by means of dye tests, or otherwise, immediately after installation or after any replacement or alteration in design.

OPPORTUNITIES FOR SANITARY ENGINEERS

Many details have necessarily been omitted in this discussion, but enough has been given to demonstrate two important facts:

1. Milk sanitation is a problem that now requires and in future will increasingly require the serious attention of sanitary engineers. It is rapidly becoming apparent to state boards of health that their sanitary engineering divisions should be related to the problem of milk sanitation. Information collected by the Public Health Service shows that in at least 25 states milk sanitation work is now being done by the divisions or bureaus of sanitary engineering, whereas two decades ago only one or two state sanitary engineering bureaus interested themselves in the problem. A similar tendency is beginning to appear in some local health departments. The total number of sanitary engineers engaged in milk control in this country is now:

(*a*) By state boards of health—17 full time and 75 part time, and

(*b*) By local boards of health—14 full time and 36 part time.

This paper should not be understood to imply that only public health engineers should be employed in milk sanitation. That would be as unwise as to insist that only veterinarians, or only bacteriologists, or only epidemiologists, or only dairying graduates should be employed in this field. Nor should this paper be understood to imply that all milk sanitation work must necessarily be under the administrative direction of a sanitary engineer. The capacity for administration does not reside solely in any one profession. If a state board of health employs more than one individual in milk control, the one who shows the best administrative capacity should be placed in administrative charge, irrespective of whether he is engineer, veterinarian, bacteriologist, epidemiologist, or dairy expert.

Nevertheless, it seems inescapable that every state health department without exception should employ at least one sanitary engineer full time on milk sanitation work and, where possible, the milk control work should be a function of the state sanitary engineering division. Except in the case of large cities which employ their own sanitary engineers, no pasteurization plant should be constructed or reconstructed and no pasteurization equipment should be installed or modified without the approval of the milk sanitation engineer.

2. Sanitary engineers should be adequately trained to discharge their milk sanitation functions. Even today most of the sanitary engineering students graduate without the necessary specialized training, and it is believed that every institution which prepares men for the sanitary engineering field should ponder the desirability of including milk sanitation as one of the subjects of instruction.

Those sanitary engineers who have already graduated and who wish to undertake milk sanitation work, should either attend postgraduate courses in milk sanitation or one or more of the short courses or seminars which are being conducted by various state boards of health and by the Public Health Service.

The Manufacture of Iron and Steel

Part I—Production of Pig Iron, and the Principal Methods of Purification

By F. H. Frankland

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BACK of the I-beam, the casting, the drill bit, is a manufacturing technique so precise that the chemical properties of the product can be specified in hundredths of a per cent. Even so, says Mr. Frankland, there is every reason to believe that the manufacturers of steel will continue to improve their metallurgical processes and to increase the uniformity of their product. In this article and the one to follow it, Mr. Frankland presents a remarkably concise, yet comprehensive, picture of present-day practice in this great industry. The current article covers the production of pig iron and the various methods of purification—the Bessemer, the open hearth, and the electric. Part II, to appear in the May issue, will take up the story at that point and continue through the manufacture of such products as structural shapes, pipe, plates, and sheets.

THE two words "iron" and "steel" have been used extensively to mean the same thing, and it is difficult to define the distinction between them. However, in a general way it may be said that "steel" indicates a more refined state of the metal than "iron," and the term is applied to all refined ferrous metals other than pig iron, cast iron, and wrought iron. Steel may readily be distinguished from wrought iron because it can be hardened and tempered, whereas wrought iron cannot.

Under modern production conditions, the first state of iron after refinement is usually called steel, and it is a popular but mistaken conception that a further refinement of the steel produces wrought iron. As a matter of fact, in early times wrought iron was developed directly from the ore in a plastic condition; and it was only after many centuries that iron could be produced from the ore in a molten condition, which permitted its being poured into molds to form castings.

Iron ore production of the world in 1936 amounted to 169,000,000 gross tons, of which approximately 50,000,000 gross tons were produced in the United States. The iron ore produced in this country in 1936 was about double that produced in 1900. Steel ingots and castings produced throughout the world in 1936 amounted to 122,000,000 gross tons, of which 48,000,000 gross tons were produced in the United States. The distribution of the use of steel, computed from final production figures for the year 1937 as compiled by *Iron Age*, is shown in Table I.

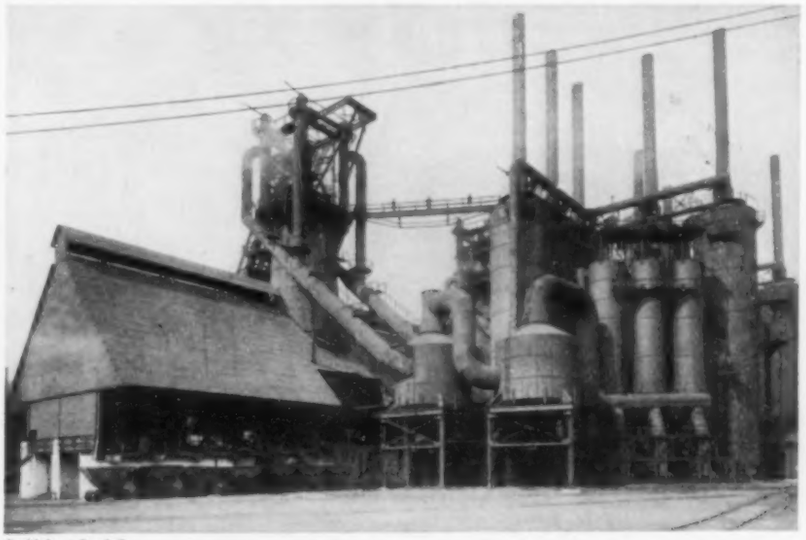
In the early part of the fifteenth century the first masonry furnace using the basic principles of the modern blast furnace was built in Europe, and this type of furnace was introduced in England about a hundred years later. Prior to this, all refinement was accomplished by hand puddling and forging, and it was only after the furnace method was developed that the metal could be produced in quantities large enough to use for castings. In fact it was impossible except by use of the furnace method to develop temperatures high enough to melt the material.

Following this, and for nearly three hundred and fifty years, the methods of refinement were limited to puddling in small reverberatory furnaces from which the product was removed in the form of a puddle ball and subjected to forging. The next outstanding advance was the Bessemer converter, developed in the 1850's in England by Henry Bessemer, and simultaneously in this country by William Kelly of Eddyville, Ky. Bessemer's financial backing enabled him to absorb his American contemporary and the process has since borne his name.

While Bessemer was developing his converter, William Siemans was working on the development of the open-hearth process, and built the first gas-burning furnace of this type in 1862. The success of the Bessemer process, even with its limitations as fixed by the nature of the ores required, established the fact that an almost unlimited market existed for an economically produced steel. This resulted in the vigorous development of the open-hearth process, which was not so restricted as to the materials used, and although the process is slower than the Bessemer, the product is more uniform in chemical and physical properties. Both processes made possible the casting of large ingots from which various shapes could be rolled, and by 1892 wrought-iron

Table I. Distribution of Use of Steel in 1937, in Percentage of Total Production

Railroads	12.0
Buildings	7.9
Automotive	17.4
Oil, gas, and mining	5.3
Agriculture	3.4
Containers	9.8
Machinery	3.8
Exports	7.2
Highway	1.1
All other	32.1
Total	100.0



Bethlehem Steel Co.

A Blast Furnace at Bethlehem, Pa.

Carnegie–Illinois Steel Corp.

MIXER-TYPE AND OPEN-TOP LADLES USED FOR TRANSPORTING MOLTEN IRON FROM BLAST FURNACES TO OPEN-HEARTH FURNACES

structural shapes were replaced by the new and superior product. This development made possible the rapid change that took place in the sky line of our cities and the bridging of many of our wider and deeper rivers. Following the open hearth came the electric furnace, which is capable of producing a material of almost any preconceived chemical analysis—though so far at a cost that prevents its competition with the open hearth for ordinary structural grade steel.

The remarkable precision of chemical and physical properties that is uniformly attained in the production of steel is unknown to any other basic industry, and is illustrated by the fact that the chemical properties are

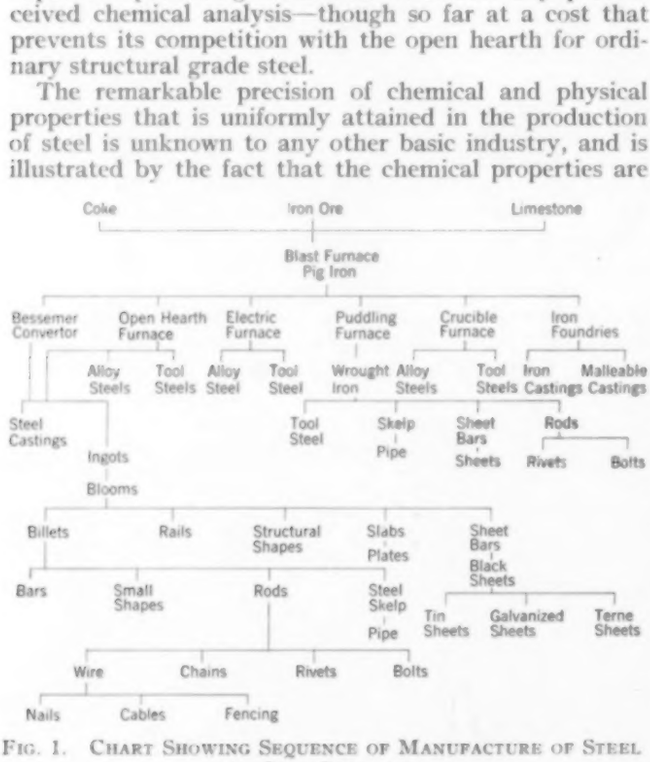


FIG. 1. CHART SHOWING SEQUENCE OF MANUFACTURE OF STEEL AND IRON PRODUCTS

expressed in hundredths of a per cent. Throughout all the processes of treating the ore and finishing through the furnace, great care is used in the selection of the fluxes, and of the furnace linings by means of which the chemical properties of the material are controlled. The proportion of Bessemer steel used for structural purposes has steadily declined so that today it is practically unobtainable except for a small tonnage of small structural shapes.

The sequence of manufacture of steel and iron products is shown in Fig. 1. The extraction of iron from its ores requires charging a mixture of ore, fuel, and flux in predetermined proportions through an opening at the top of the blast furnace, while heated air is blown in through openings (tuyères) near the bottom. The nitrogen in the air, together with the products of reduction, pass upward and escape through openings at the top. This part of the process is continuous and necessitates the removal of part of the impurities in the form of slag, and also the removal, from time to time, of molten iron through an opening at the bottom of the furnace.

In charging the furnace, coke is first placed on the bottom to a height just below the tuyères. Charcoal, or some other easily ignited material, is then placed, and on top of it is laid a large quantity of coke with enough limestone to flux the ash. Ore is then gradually placed with a carefully controlled quantity of flux. The initial amount of coke is usually equal to about half the cubic contents of the furnace. When the furnace has been filled to what is known as the "stock line" it is ready for lighting. As the burning continues, additional ore, coke, and limestone are added from time to time, the proportions of the various materials being varied to meet ever-changing conditions. These charges are governed by observation and by analysis of the pig iron and slag produced.

In from 10 to 15 hours after the air blast has been turned on, the molten slag floating on the iron has accumulated in sufficient quantity to tap. From 30 to 40 hours are required before the iron is ready to tap. Then the molten metal is run off into ladles. During this flow, samples for chemical analysis and fracture tests are taken. From the ladles the metal is poured into the pig casting machine.

THE FIVE PRINCIPAL METHODS OF PURIFICATION

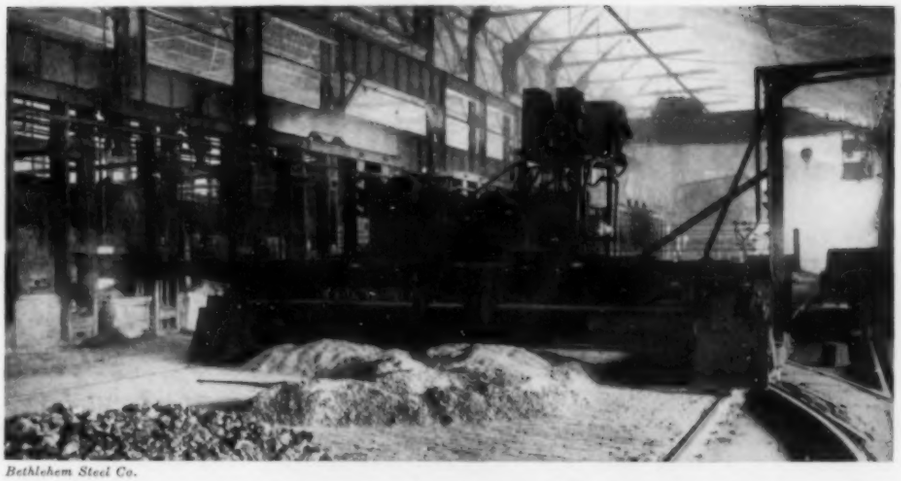
Pig iron is purified by oxidation—except in the electric furnace, which employs a method of both oxidation and reduction. In the process of purification either air or iron oxide may be used. In both the Bessemer and the open-hearth processes purification may be accomplished by oxidation alone, in which case it is called the "acid process." If oxidation is accompanied by the use of a limestone flux it is called the "basic process."

There are therefore five principal methods of purification—acid Bessemer, acid open hearth, basic Bessemer, basic open hearth, and electric. The product from each method differs somewhat, and with the exception of the electric process, each requires a pig iron of a different composition. Because of the nature of the iron ores of this country, the pig iron produced here is most suitable for treatment by the basic open-hearth or the acid Bessemer process, and consequently nearly all our steel is produced by one or the other of these two processes. Practically

Jones and Laughlin Steel Corp.

TAPPING A BLAST FURNACE

all our structural steel is manufactured in the basic open-hearth furnace, and most of the acid Bessemer product goes either into small shapes and bars such as are used for agricultural machinery or—because of its free machining quality for cutting and threading—into steel skelp from which pipe is made.



Bethlehem Steel Co.

CHARGING AN OPEN-HEARTH FURNACE

Scrap and Raw Materials Are Fed Into the Furnace by the Ram on the Traveling Machine

WROUGHT IRON

Strictly speaking, wrought iron is a variety of commercially pure iron obtained directly from the ore in a pasty condition. Wrought iron, in its commonly known form, is not the purest form of commercial iron, for dead soft steel and ingot iron, both produced in the open-hearth furnace, contain a smaller percentage of impurities. Its composition is, essentially, refined metallic iron and a uniformly distributed percentage of slag.

Wrought iron, nowadays, is produced by many different processes. In *The Making, Shaping, and Treating of Steel*, by Camp and Francis, it is stated, "by whatever process, it (wrought iron) is always obtained in a pasty, or semi-fused condition, and in masses, or bodies, composed of cohering granules partially surrounded by slag. In mechanically working these sponge-like masses, the granules of metal are elongated and more or less welded together, while a large portion of the slag is squeezed out of the mass and the rest remains as thread-like but irregular masses intermingled with the iron." Due to the condition just described, wrought iron has a fibrous structure, imparted by the slag, which is readily shown by the etching test.

The usual methods of production used to be the hand-puddling furnace and the direct-from-the-ore process, although there are several indirect processes. However, the demand for wrought iron has fallen to such a point that production by these processes is nowadays relatively insignificant. By the modern Byer's process, wrought iron is economically produced by the refining of pig iron in a Bessemer converter. The requisite slag is obtained from open-hearth furnaces and is poured into a ladle, and the molten iron is slowly added, while the ladle is rocked so as to produce a uniform distribution of iron and slag. The resulting spongy mass is worked through a press and squeezed into a bloom ready for the rolling mill.

THE BESSEMER PROCESS

The Bessemer process for the purification of pig iron is the simplest. The air blast in the converter oxidizes a portion of the iron, all the silicon and manganese, and then the carbon. When oxygen is combined with the iron, silicon, and manganese, slag is formed, and the carbon passes off in the form of gases—carbon monoxide and carbon dioxide. If the process stopped here without recarburization, deleterious oxides would remain and render the steel unfit for use. Hence carbon and other deoxidizers are added to the metal after blowing. When the metal is subjected to full blowing, it is usually "hot short"—that is, brittle in hot working—unless manganese, in the form of spiegeleisen (a low grade of ferro-manganese), is added. This use of manganese makes it possible to produce mild or soft steels by the Bessemer process.

In modern steel mills the converter is usually charged with molten iron direct from the blast furnace. In some older mills, however, pig iron is still used. In such cases the iron must first be melted in a cupola, in which the charge is composed of coke, spiegeleisen, and pig iron, in alternate layers of metal and coke; and to the coke is added limestone flux to get rid of the ash.

Production of Bessemer steel dropped from 6,000,000 gross tons in 1922 to 3,500,000 gross tons in 1936, a reduction in 14 years from about 16.5 to about 7.5 per cent of the total steel produced.

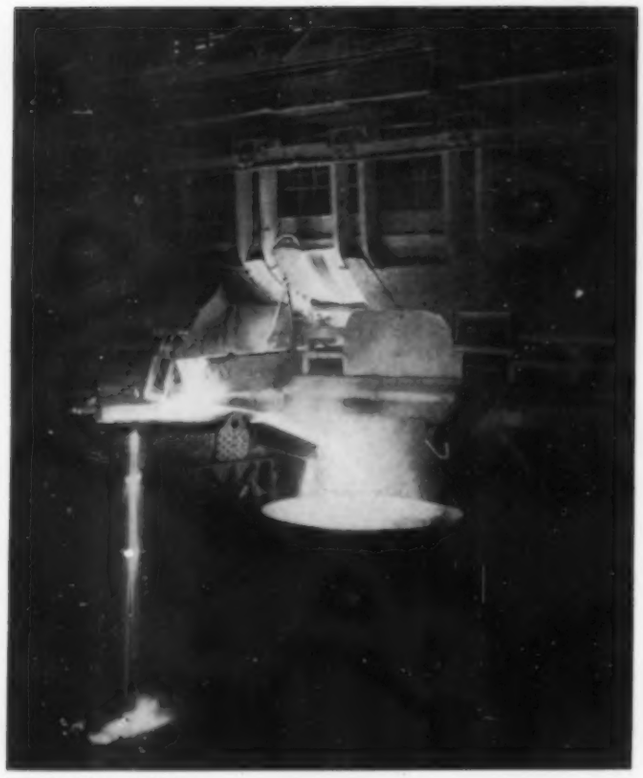
THE ACID AND BASIC OPEN-HEARTH PROCESSES

The open-hearth process now involves the use of a rectangular covered furnace with a large shallow dish-like hearth to contain the charge of pig iron, iron ore, and steel scrap, with limestone for fluxing purposes. The fuel used is gas, mixed with sufficient preheated air to obtain the necessary high temperature to melt the charge. The furnace is fired alternately from each end, so that at all times the incoming gases are absorbing heat from the brick in a checkerwork chamber that has previously been warmed by the stack gases.

Jones and Laughlin Steel Corp.

TAKING A TEST FROM AN OPEN-HEARTH HEAT

Whether the acid or the basic open-hearth process is to be employed depends largely on the nature and amount of the impurities in the pig iron. If the latter is high in sulfur and phosphorus, a basic flux (that is, one containing limestone) must be used. On the other hand, iron low in sulfur, phosphorus, and other impurities is susceptible to treatment by the acid process, which employs a flux containing silica. Naturally, since iron that can be treated thus is purer to begin with, the time for



Carnegie-Illinois Steel Corp.

TAPPING A 160-TON HEAT OF STEEL (OPEN HEARTH)
Molten Slag Is Overflowing Into the Ladle at the Right

completing a heat is shorter with the acid process than with the basic.

In most modern open hearths the iron is added in a molten state, direct from the blast furnace. In some cases where the blast furnaces are not situated in the same plant as is the open hearth, the hot metal is conveyed in hot-metal cars.

The purification of the hot metal in the furnace is accomplished by the oxidizing brought about by the iron oxides and the limestone flux. Both oxidizing agents operate concurrently, but the action of the iron oxides takes effect prior to that of the flux, as the acid impurities must be oxidized before they can be neutralized by the flux. During the period of the purification process known as the "lime boil," the carbon content of the molten metal drops rapidly and tests are made at intervals in order to control the carbon so as to produce accurately the percentage specified.

Molten metal, when ready for pouring, is at a temperature of about 2,900 F. It is run into a crane ladle, in which the necessary additions of carbon, manganese, silicon, or other alloying elements are made to produce a steel of the specified analysis. The ingot molds are then filled with the molten steel poured direct from the ladle. The ordinary capacities of open-hearth furnaces usually range from 50 to about 100 tons of hot metal, although some of the more modern furnaces at the larger mills have a capacity of well over 100 tons.

Of a total of about 29,000,000 gross tons of open-hearth steel produced in 1922, about 28,000,000 tons were basic and about 1,000,000 tons acid steel. In 1936 open-hearth production totaled over 43,500,000 tons, of which over 43,000,000 tons were basic and less than half a million tons acid.

OTHER REFINING PROCESSES

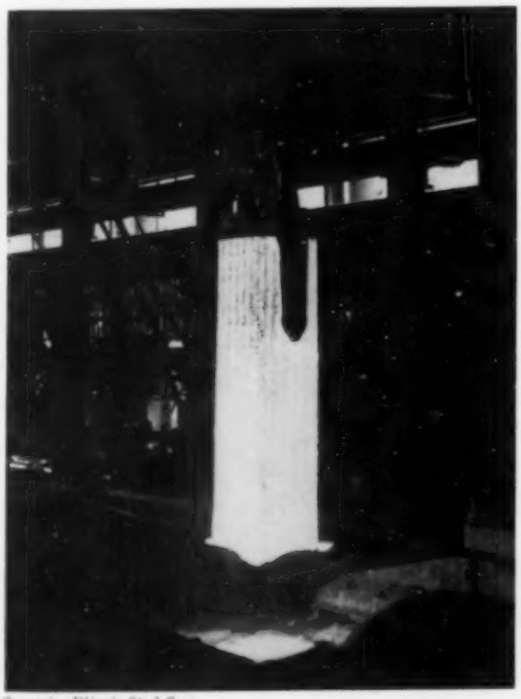
The electric furnace is at present principally used in the production of alloy steels, such as stainless steel, and the furnaces are usually from $7\frac{1}{2}$ to 25-ton capacity. The heat applied by electricity has no electro-chemical effect upon the steel being produced, and therefore a very close control can be maintained over chemical characteristics. The charge is kept from contact with the air by a protective blanket of slag. For reasons of economy of operation, the electric furnace is generally used for the final refining stages in making steel, the hot metal charge coming from an open-hearth furnace.

There are two principal types of electric furnaces, the inductive type and the arc type. In the inductive furnace the molten metal acts as the core of a secondary wound coil, and the primary circuit is wound on a core corresponding to the core of a transformer. In the arc-type furnace, of which there are several varieties, the molten metal constitutes one of the electrodes.

It is interesting to note that Sir William Siemens constructed the first electric furnace of any practical importance as far back as 1878, and that the Heroult furnace was patented in 1886, but it was not until 1906 that the first electric furnace for commercial production was built in this country, and in 1909 there were only 10 arc and 10 induction furnaces in use. Production of electric steel on a scale of any magnitude started in 1910, when over 52,000 gross tons were produced. Production by this method received a great impetus during the years of the World War, and by 1936 it had increased to over 772,000 gross tons.

Mention should also be made of the crucible furnace, which is used only in the production of some of the tool steels and certain specialized alloy steels. Crucibles are generally large enough to hold several tons of molten metal; they are sometimes made of clay, but are more commonly of a graphite composition.

The raw materials of the charge are generally put in the crucible, which is then set in a hot furnace until the charge is melted. However, molten metal produced elsewhere may be poured into the crucible for further processing in the furnace. The production of crucible steel in the United States dropped from about 122,000 gross tons in 1910 to about 44,000 in 1923, and to about 800 tons in 1936.



Carnegie-Illinois Steel Corp.

LIFTING AN INGOT FROM THE SOAKING PITS, WHERE IT HAS BEEN HEATED FOR ROLLING

Constructive Suggestions for Improving Professional Status of Engineers

A Digest of the Formal Discussions Prepared for the January 1939 Symposium of the Committee on Professional Objectives

THE March issue of "Civil Engineering" carried the four "main papers" of the program sponsored by the Committee on Professional Objectives at the 1939 Annual Meeting. Those papers were essentially fact-finding. The first three described the methods and plans of the architects, the lawyers, and the doctors, for improving the professional, social, and economic status of their respective professions; and the fourth analyzed the situation with specific regard to the civil engineering profession.

With the facts thus assembled, the ensuing discussers at the Annual Meeting turned their attention to the question of what can be done to enhance the status of the civil engineer. The six formal discussions, approaching the subject from as many different angles, are presented here. They contain many practical suggestions for action which may be expected to bear fruit in the definite, long-term program now being formulated by the Committee on Professional Objectives.

Lessons to Be Learned from the Other Professions

By D. C. WALSER, M. AM. SOC. C.E.

VICE-PRESIDENT, CHARLES B. HAWLEY ENGINEERING CORPORATION, WASHINGTON, D.C.

THE PAPER on professional activities of the architects, presented by Mr. Sullivan, indicates clearly that the problems confronting the architectural profession, as well as its efforts to solve them, are very similar to those of engineers. I am heartily in agreement with the idea of the American Institute of Architects that the national organizations representing the generally recognized learned professions and the fine arts should join in an inter-professional conference at which topics of general interest to the professions as a whole might be discussed. Concerted action on the part of these national organizations, working through their local sections or chapters, should add considerable prestige to any movement promulgated.

The medical profession has its problems also, but as this profession has to deal directly with human life, a large number and variety of legislative enactments bearing on its practice have been placed upon the statutes. The civil authorities in charge of operating the various federal, state, municipal, and county governments have never hesitated to spend money for enforcing these statutes and bringing violaters to trial. This is not true of the architectural and engineering professions and is, no doubt, to a high degree responsible for the lack of success of registration. Most registration laws have no enforcement features and, because of lack of money, the organizations interested therein have not in the past been able to bring legal action against any individual guilty of malpractice—except possibly in New York State.

In my opinion, enactments with "teeth" in them have been responsible for the strict requirements of the medical profession, not only for increasing the pre-college requirements but for extending the courses to secure a doctor's degree. The time and cost required for a doctor to receive a certificate to practice medicine is, no doubt, one of the major reasons why that profession is not overcrowded and has not encountered the problems with its younger members that the architects and engineers have.

With regard to the legal profession, college requirements for securing a legal degree have also been greatly increased. Most of the recognized law schools now require five years of college work. In a recent address, William C. Van Vleck, dean of the law school of George Washington University, stated that in suburban districts, small towns, and so forth, the income of the legal profession was ample and its members occupied a high position in the community. True, in large metropolitan sections there is a very crowded condition, but it has not as yet reached an acute stage.

It has occurred to me that many youngsters on entering college do not know just what profession they wish to follow, and as a last resort they decide to take up engineering. The Census figures since 1910 show some interesting facts about the various professions. The following table, compiled from that source, shows the rates of growth, in per cent, over the ten-year periods 1910–1920 and 1920–1930. What this growth has been during the past eight years, with a large increase in enrolment in colleges and universities, is open to conjecture.

PROFESSION	1910–1920	1920–1930
Architects	9.3	21.0
Civil engineers	24.2	59.0
Electrical engineers	77.7	113.5
Mechanical engineers	160.0	44.0
Mining engineers	3.5*	79.0
Physicians and surgeons	4.0*	6.2
Dentists	35.7	26.8
Lawyers	6.9	30.7

* Denotes decrease

It will be noted that the rate of growth in the various branches of the engineering profession is very outstanding when compared with the medical profession.

So far as the civil engineering profession is concerned, it is only during the past decade that the welfare of the individual has actually demanded attention. It seems to me that the Society has set the machinery in motion to cope with this problem by its sphere of activities during the past twenty years, which has included the formation of Local Sections, increased interest in the junior organizations, and the installation of Student Chapters in many of the recognized schools and colleges. Through these contacts, the Committee on Professional Objectives should be in a position to promulgate some plan that will benefit the economic status of the younger members.

I submit herewith a few additional suggestions for the consideration of this committee:

1. An increase in the corporate membership of the Society is desirable, but the existing requirements for such membership should not be lowered.

2. The college course should be increased to five years, adding cultural subjects to the curricula so that the engineer will be as well grounded in social activities as in technical work. This may work a hardship on some young men but it will not deter those who are sincere in their desire to follow engineering as a profession. It might be advisable to ascertain whether a student entering an engineering college is properly qualified and has the proper aptitude. A great deal has been done in educational circles within late years in devising and conducting examinations of this character, and they should be put to use.

3. Some definite plan should be inaugurated with respect to the rating of engineering departments and offices in states, counties, and cities. This plan, which should be susceptible to modification due to geographical and climatic conditions in different sections of the country, should be submitted to the Local Sections so that they may appoint a live and forceful committee to put the necessary machinery to work. In my judgment, this plan should be made a major activity of every Local Section.

4. The junior engineer presents rather a difficult problem. During the past eight years, a large number have not had the opportunity to secure the type of employment which would provide the requirements necessary to transfer to the grade of associate when reaching the age of transfer. In many localities, a large number of contractors and subcontractors employ high school graduates as time-keepers, and carpenters as foremen and superintendents. This is a field for our Society to look into—and it would be a problem for the Local Section to solve. In Washington, we have two organizations which could materially aid in this activity. One of these, the District of Columbia Council of Engineering and Architectural Societies, comprises ten or eleven technical societies, including the architects'. It was through the efforts of this group, working over a period of about two years, that a registration bill was drawn up for presentation to Congress, which met with the approval of most of the organization members as well as the Commissioners of the District of Columbia. Such an organization is powerful through its unity of thought and concerted action. Another outlet is the Washington Building Congress. (I understand that similar congresses have been organized in several of the metropolitan districts.) Its membership consists of architects, engineers, construction men, the building trades, and so forth. It occurs to me that if the engineers in such a group were to present the "junior engineer" problem to their congress, they would have no trouble in securing the cooperation of the construction men in employing graduate students, thus giving the student an opportunity to follow the line he has selected, and once in that line, a better opportunity to grow up in the profession and transfer to other jobs.

5. Many students enter engineering colleges in order to secure a thorough technical training with the idea of branching out into lines of activity other than purely engineering work. A large number, however, after receiving a degree in engineering, decide to follow it up. I suggest that the Committee on Professional Activities might work with the placement bureaus of engineering colleges and develop lines of endeavor for which such men would be better qualified. If such an idea is feasible, it would tend to relieve the overcrowded condition of our profession.

Commercial or Professional?

By STANLEY H. WRIGHT, M. AM. SOC. C.E.

REGIONAL ENGINEER, REGION 3, PWA, ATLANTA, GA.

IT WOULD seem that we must recognize a sharp distinction between objectives that are related but divergent. It is one thing to endeavor to raise the economic status of the engineer, and another, perhaps a more difficult one, to raise his professional status. The ideal to be accomplished is to raise both, but it is my opinion that the first objective, in the long run, is dependent upon the second, and that the order of importance is inverse. If this is true we must establish our professional status first.

It would appear to me that as a class we are not professional minded—we are professionally illiterate in comparison with medicine and law. Even by accepted standards, engineers are not recognized as professionals since there are only three so-called learned professions—law, medicine, and theology. We can more readily claim kinship with magicians who defy the elements and produce something out of nothing.

One finds an interesting speculation in the fact that the church, the law, and medicine have perpetuated a uniformity of language; their more secret themes are expressed in a language with which the average engineer is scarcely acquainted. Algebra does not imply so much of the influence of culture as does Latin. Let it be said that too few of us can speak or write correct English. Only in recent years have our engineering colleges generally recognized this great fault. A review of many reports and letters prepared by average engineers will stop the breath with astonishment.

Professional men are not judged by their works alone. When after six or eight years of intensive study the young lawyer or doctor has secured his degree, has been admitted to the bar or has taken the Hippocratic oath, he is ready to practice. The engineer at the same time is also "practicing"—practicing eating beans with a knife in some construction camp. This field experience of young engineers, often covering a period of years, has no analogy in the other professions. The military or naval engineering graduate, as an officer, escapes it or conducts his work in a manner befitting an officer. But the "civil" engineer, to become what "professional" implies, must come up through the civil ranks to his professional place. Some manage it; others, without grace or tradition, never achieve it.

One is almost led to believe that the professions after all are materially influenced by heredity and environment. Think of the ancient heritage of the accepted professions as against the early environment of the young engineer. To overlook tradition is to overlook a powerful force in the shaping of professional lives. Tradition by the way, is the "transmission of knowledge, opinions, doctrines, customs, and practices, from generation to generation, originally by word of mouth and by example; a body of beliefs and usages handed down."

The young lawyer or physician by tradition is given a social and professional prestige accepted by all with whom he comes in contact. The engineer, if he attains prestige, usually does so by reason of his social acceptability rather than by reason of his professional accomplishments, unless he has achieved most unusual prominence.

Our wistful longing for a professional status or for professional recognition, our as-a-man-thinketh-so-is-he attitude, may be assuaged by the written or spoken words

in erudite papers, in resolutions, and in committee reports; but, before others will see us as we see ourselves, these must be augmented by years of conservative practices as professional men, individually and collectively, and by ethical conduct that none can ignore.

The Value of Registration

By H. M. JONES, M. AM. SOC. C.E.

SECRETARY, CALIFORNIA STATE BOARD OF CIVIL ENGINEERING EXAMINERS, LOS ANGELES, CALIF.

IT APPEARS axiomatic that the professional, economic, and social status of the engineer is so fundamentally dependent upon public opinion that it cannot be advanced without the public's justified conviction as to the merit of such advancement. The general public's appraisal of the required technical training, the qualifying experience, and the acumen of the engineer fixes his professional status; his commercial value to society fixes his economic position; and his demeanor and personal habits fix his place in the social scale. To secure the desired appraisal will require the focusing of public attention on the professional engineer, as such, by a proper public relations program.

Generally, the professional engineer has given little concern to those calling themselves engineers, or to those who practice engineering, or to how such practice is conducted, with a result that the group commonly known as the engineering profession has actually a most heterogeneous personnel. Many have found it expedient to call themselves engineers when their training and experience, or even their activities, have no relation to engineering; and persons engaged in subprofessional occupations, such as surveyors and draftsmen, have almost without exception been known as engineers. Yet the engineering efforts of many in this miscellaneous group have been marked by gross incompetency. Thus the professional engineer, comprising a probable minority of this broad and general classification, has been subject to mass appraisal without the appraiser's knowledge of what actually constitutes professional engineering.

Advancement of the professional, economic, and social status of the engineer awaits the time when he can pass in public review without the impediment of satellites. Conceivably this would be when technical standards for those who practice have been established and are maintained; when the professionals are separated from the subprofessionals and from usurpers of the professional prerogative; when aggressive control of improper practice and conduct is an actuality; and when there is a positive prohibition against the practice or attempt to practice engineering by any but qualified persons.

State regulation of the practice of engineering, commonly called engineering registration, seems at the moment one of the primary and desirable agencies through which to accomplish this end. Obviously no law is better than its administration, but in their abstract form the registration laws of the several states are at least capable of technically qualifying applicants; restricting the use of the title "engineer"; applying disciplinary action for malpractice; and prosecuting, criminally, those who practice or offer to practice without the proper authority.

Experience with engineering registration has served to illustrate its potentialities. For example, practical qualifying examinations, not of the collegiate type but rather a developed series of selected practical problems, have been given. The examinee is called upon to recognize the theory involved and to proceed with the solution, using the proper principle with good engineering judgment under conditions which approach those encountered in actual practice, save access to advice from others.

As another example, persons using such titles as appraisal engineer, structural engineer, and sanitary engineer when they have been, respectively, a real estate salesman, a building contractor, and a plumber, have been definitely stopped from so styling themselves.

Cases of complete revocation of registration, suspensions, and reprovals serve as evidence that positive disciplinary action is an effective remedy for improper practice and conduct. And finally, prosecuting officers have been willing to issue warrants for arrest, to prepare and try cases against those accused of practicing without authorization or using the title engineer illegally, upon the presentation of proper and sufficient evidence. Judges and juries alike have not failed to render verdicts within the meaning of the law and consistent with the evidence submitted.

No claim is made that registration today is contributing more than an appreciable help toward public recognition. Compared with statutory regulation of several other professions our regulation of practice is relatively new and perhaps for this reason is lacking in comparable accomplishments. It is believed, however, that it has provided some foundation upon which future professional welfare procedure can be based, and has established itself as a proper agency for the continuance of this work.

The effectiveness of registration as an instrument for the promotion of engineering welfare is dependent upon the completeness of its acceptance and use by the profession. This seems true both as to the summation of accomplishments and as to the time necessary for their fulfillment. From observation it seems probable that an extended and modified type of the so-called Model Law would be productive of more satisfying results. The law might, for example, make provision for vesting the administrating authority in a public corporation controlled by the profession, providing greater latitude and more flexibility in the control of professional practice, and using the public corporation as an agency to transact such business of the profession as could not or should not be transacted by the Society or its Local Sections.

Unionization?

By VAN TUYL BOUGHTON, ASSOC. M. AM. SOC. C.E.

MANAGING EDITOR, *Engineering News-Record*, NEW YORK, N.Y.

IN CONNECTION with the professional status of engineers I want here to discuss certain elements of the union situation which seem to be of special importance. The union question is a more serious one for engineers than for any other profession, so far as I can see, because of our much wider connections with all fields of industry and the fact that a large majority of engineers are employees in grades below the executive grade. I think the union question also is a more concrete problem for the engineering profession because many young engineers, especially those in the mechanical and electrical fields, have to take jobs in big industries that are almost completely unionized.

That is why we should not waste time in theorizing about the unionization of engineers. We must recog-

nize that joining a union may be necessary in order for an engineer to get a job or to hold one. A young man put that question to me just recently. He said he did not wish to join a union, but if it meant his job, he was going to.

I do not think we need to worry about the unions that are made up of men in subprofessional positions. They serve a useful purpose in helping to keep these men from being exploited. If their standards are low, they will not attract many professionally minded men, but if they raise their standards to the point where the unfavorable characteristics of the trade union largely disappear, then there will remain little cause for concern.

What should give the profession concern is the formation of unions made up exclusively of licensed engineers. I do not think that such unions will last long, for their objectives would appear to be entirely selfish; but the recent formation of one such group has served to point out that there can be unions which can legally use the words, "professional engineer" as part of their name. Such unions, affiliated with unions of the trades whose work the engineers must pass upon, would be very detrimental, both to the profession and to the public, and so their formation is to be resisted.

We can meet this situation by a more than passive interest in the problems of the licensed engineers whose problems seem easiest solved by collective action. What we do in the next few years is crucial because we are now near the peak of the unionization movement. If we can check the development of such unions now, the chance of their development in the future will be materially reduced.

The Wagner Labor Relations Act, which has stimulated so much of the present movement, actually guarantees rights to the worker which heretofore he could maintain only through the support of a union. In the long run, that very guarantee will weaken the hold of the unions. That will be especially true in the case of the smaller groups, such as the employed engineers and architects. Strong state societies of professional engineers, aided by the local sections of the national engineering societies, should be able to answer so many of the economic problems of these groups as to make it unnecessary for them to seek the aid of trade unions. I cannot imagine the professionally minded man seeking the support of a trade union except as a last resort. Give the young men real aid in meeting their economic problems and there will be no need to worry about any deep intrusion of trade unions into the engineering profession.

Comments on Salary Studies, and on the Teaching of Speech and Ethics in Colleges

By F. N. MENEFEE, M. AM. SOC. C.E.

PROFESSOR OF ENGINEERING MECHANICS, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.

IT MAY be impossible to successfully isolate some single satisfying reason why the matter of professional status among engineers is so unsettled; why by comparison the engineer feels that other callings are more professional. I believe, however, that a large part of the difficulty lies in the engineer's rigorous mechanical training, with little or no training in the importance of correctly presenting himself to the public with which he works and lives. Putting it in another way, the human qualities of the architect, the lawyer, and the doctor are closer to the surface, more apparent, and more easily grasped from casual or professional contact.

If this is correct, it appears that we must base our plan upon training the engineer unostentatiously to present his good human qualities to the public. No one questions the technical qualifications of the engineering mind in the United States. Our success in elevating the engineer to a higher professional status will be largely a matter of the amount of training in some of the simpler matters of everyday personal public relations.

In fact, a successful professional society is an educational institution of both undergraduate and graduate quality. Like a college, it has certain qualifications for admittance, and it is a device for bringing people together who want to learn from each other and from older and wiser persons found in the group; likewise we might compare the grade or rank of membership with the class in college and note that there are studies and papers and recitations and criticism of the constructive type, honors, and so on.

Today, as in the formal educational institution, we have brought in some outside lecturers. From Mr. Sullivan we learn that the American Institute of Architects has established standards of fair compensation for the architect's services. Since fair compensation for services is undoubtedly a justifiable objective of our Committee on Professional Objectives, let us consider how the statement applies to civil engineering. On comparable work, such as plans for water works, sewage treatment plants, water power, and bridges, the professional or consulting engineer usually gets his compensation on a percentage basis. I presume it would be fair to say that the American Society of Civil Engineers "established" our standard rates. If it did not, it at least approved them and published a manual for whatever benefit members of the Society could get from it.

I have often wondered why our Society stopped with the consulting and designing engineer. Was it because the architects stopped there? Possibly if each and every city in the land had a city architect, the architects would have said, "We had better devise some plan for establishing a standard of fair compensation for city architects." There is just as much logic in the idea of fair compensation for the city engineer as for the consulting and designing engineer. Surely the public is entitled to just as much for its money in the way of proper sanitation, well-operated and efficient water works, as it is in good-looking and safe buildings for schools, auditoriums, and so on.

At any rate we, as individuals, endorse the idea that a city employ only a graduate engineer in the capacity of city engineer; we expect of him a thorough training and ability to master whatever additional knowledge is necessary, from accounting, fire and police protection, to landscape design and management of welfare. If through the activity of our Committee on Professional Objectives we could give the city engineer and his staff a little attention in our booklet, give him a little of the freedom that the city attorney enjoys, cities would benefit, engineers would benefit, and the professional status of the engineering group would be enhanced. I would suggest that we bring together statistics on municipal engineers' salaries and duties and develop therefrom a recommended salary scale depending on the population, kind of community, and so on.

Mr. Sullivan refers to the social consciousness of the architect, and I should say that social consciousness was, theoretically at least, along with learning, an ingredient of what was meant when the word "profession" came

into being. I have no quantitative figures on the relative social consciousness of engineers as compared with men in other professions, though I suspect they would rank high if a way were devised to measure this quality. But I am very sure that they would rank low in being readily recognized by the general public as having social consciousness. The doctor takes first place in the hearts of the people on the score of "service." The lawyer cannot only think and analyze, but can stand up and sway opinion through the emotions; and this quality with others, helps to rate him as "learned" and hence admit him to professional status. The architect can take the research of the engineer, and put it into a sketch of a building or bridge which captivates the eye of the public; and this gets him the job and puts him in the professional class.

The engineer cannot possibly get as close to his client as can the doctor. In its deliberations, our Committee, for the time being at least, can leave the doctor's approach out of consideration. And it is generally conceded that there are too few engineers who can "emote" for us to try development along that line. But it is becoming recognized in the engineering colleges that engineering students can be interested in developing their talent in public speech and in raising their personality quotient. At the University of Michigan, under a faculty coach, we have an Engineers' Speech Society, known by the Greek name of Sigma Rho Tau, which has from 150 to 180 engineering students actively enrolled every year. Meeting once a week for even one year, studying and practicing various speech activities, will do wonders for a young engineer. When such study is pursued for four years, as it is by many of our students, the results are very pronounced and the training will, I am sure, produce a favorable public reaction and bring about a more accurate appraisal of the social consciousness of the engineer. For with most of us, regardless of dictionary definitions, "belonging to a profession" connotes being favorably known as well as possessing book learning and rendering service.

Perhaps our Committee could study and encourage the speech movement started by Sigma Rho Tau (which now has six active chapters), and through the means of greater articulateness of the engineering group add to our professional status.

Since the matter of improving "status" is one of education within and without the profession, we should proceed in an orthodox educational manner. One project that would be of value would be to collect and edit the outstanding published discussions on the subject of ethics for engineers. (Of these our own TRANSACTIONS has many, but I would not confine the selection to papers written by civil engineers.) Then we should arrange with the deans of our engineering colleges to have copies placed on the library shelves for reference and for assigned reading and discussion in English classes and student forums. There are a surprising number of students who are anxious to discuss matters of this nature with teachers and practitioners of engineering, but few engineering colleges or societies are equipped with the proper rooms and accessories for the most successful application of the idea.

If a series for forums properly conducted by engineers throughout the engineering student's career, and extending into those few years in which he is a Junior in the Society, cannot bring him to see the fallacy of unionism for engineers—except for the sake of expediency—then we had better let him go. With a properly conducted plan, starting in the college and carried on by the Local Section, there will not be enough derelicts to worry over.

There is a tendency among engineering colleges to depart from the policy upon which most of them grew great. I refer to the employment of teachers who have served a successful apprenticeship in engineering practice. In a speech before the Society for the Promotion of Engineering Education, entitled "Instruction on Professional Life and Conduct," Daniel Mead, Past-President of the Society, deplores the lack of acquaintance, among engineering educators and purely technical men, with the unsavory side of life which continuously confronts the professional engineer. Referring to the poise required by the engineer when faced with a dishonest proposal, he said, "This lack of experience with the seamy side of professional life is the reason that instruction on professional life and conduct is not universally taught in the engineering schools of the country." Evidently Dr. Mead thinks there is now a lack of experienced faculty material from which to expect results in this important but non-technical phase of the engineer's training; if so, there is all the more reason why we should have a Committee on Professional Objectives.

Perhaps this Committee can assist in correcting the situation arising from inexperienced teachers—or at least encourage the establishment of the needed instruction in the Local Sections. But I believe there are still enough engineering teachers with professional experience—including contact with unethical or dishonest practices—to justify the encouragement of special instruction in ethics during the student's college career. Let us make a study of ways and means of arousing the civil engineering faculty man to his responsibility for providing something more than a commencement day speech on these matters of non-technical nature which are so important in the success of the practicing engineer.

The present symposium is only a small fragment of the total discussion directed to the professional status of the engineer. Other engineering groups are working along certain lines of endeavor with very creditable results. Among those whose counsel and advice should be sought is the Society for the Promotion of Engineering Education. Another is the National Council of State Boards of Engineering Examiners, which has had a background and experience in one phase of the problem that our Committee could well study if it has not already done so. Again, the Engineers' Council for Professional Development has a Committee on Professional Recognition which has made valuable statistical studies; undoubtedly this organization would welcome an opportunity to cooperate with our Committee. Finally, the American Engineering Council (which appears to correspond to the American Bar Association) is interested, and we should not fail to enlist its aid in our quest for ways and means to make engineers conscious of the multiple benefits of higher professional objectives.

The Case for the Young Engineer

By H. L. FRUEND, M. AM. SOC. C.E.

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AS ENGINEERS we like to think we use the so-called "engineering approach" to all our problems, that is, we first assemble our data and analyze our facts before we draw conclusions and offer opinions. And so we do when only physical factors are involved. But when it comes to personal matters, human relationships, social, political, and religious ideas, economic theories,

and even professional development, we throw customary caution to the winds, base our reactions and advance strong opinions purely on personal experiences and often on mere prejudice. We can build a bridge, construct a dam, or erect a building strictly on schedule, but when it comes to social problems and human relationships, the job is never done; conditions change constantly, and we are never up to schedule.

However, in so far as we can, let us try the engineering approach in the case for the young engineer. To stimulate discussion and bring forth facts and ideas, let us try the method of provocative questions.

1. The 1930 census lists 226,249 technical engineers and surveyors. Some 9,000 or more technical graduates are entering the profession each year. Is the field becoming overcrowded and should we seek to raise the average quality of engineers by limiting the supply?

2. It now takes at least four years and costs the state and family about $10,000 to turn out an engineering graduate. If we increase the period of training and the cost, can we also provide a more adequate return on the investment, not only in earnings but also in the quality and dependability of engineering service?

3. Certain groups are seeking to capitalize on an apparent deficiency in the economic status of young engineers, by stressing the value of group action and coercion. Can we ignore this trend as non-technical and maintain a professional reserve, or will we be compelled to do something about it in order to hold our professional status?

4. Employment conditions are constantly changing. More and more engineers find it necessary to work for federal and state agencies, public institutions, and large private corporations, in which the service is classified and the personnel department prefers to deal with organized groups and not with individuals. Can we as a Society help the young engineer to find and hold his place in such an economy or must we leave this field to other associations formed solely for this purpose?

5. The field for individual practice or of individual employment is becoming very limited, and the opportunity for the young engineer to set up his own office is becoming more and more remote. How can we help the young engineer to acquire both business sense and training and to make those contacts with the business world that so vitally affect his future success?

6. The old rule for success was: Pick out a good boss and rise with him. How can we, in the new order of things, foster and develop that spirit of comradeship and cooperation between engineer and cub, which many an old engineer cherishes and to which he attributes his initial success? The administrative duties of executive engineers are now so exacting that they no longer have time to develop such contacts even though they still want to do so. Can we set up in or through the Society a system of counselors to perform this worth-while and much needed service, and thus offer to young engineers the benefits of ripe experience and personal advice?

7. The days of the pioneer are over and the frontiers gone. The young engineer must now find employment in large cities and industrial centers. Unlike the initiates in other professions, few opportunities exist for him in small communities. Can we help him to become adjusted, to avoid getting lost and temporarily sidetracked in the tumult?

8. The initial work of the young engineer is being limited to one or more repetitive tasks. He is a tracer, a detailer, or a field man and becomes almost as much a feature in the production line as does the ordinary mechanic. Few have the opportunity to follow a project through from the preliminary report to final construction. How can we help the young engineer to attain the broad experience and judgment that distinguishes engineering from the skilled trades?

9. To secure the necessary wide experience, the young engineer of today often has to change jobs frequently. Sometimes there is no other way to get out of a rut. Is it possible to set up some sort of a rotating internship in industry under which the young engineer can find his proper interest and field without having to become a floater?

10. The foundation of American life is the family. More engineers have been spurred on to greater incentive by their wives than have ever been hampered by their families. Must this steadying influence be delayed by the pinch of necessity due to lack of security and low income?

11. The Society's remarkable growth came largely through the free exchange of technical data and ideas during a period of rising population and industrial growth. Now that we are approaching a period of stabilization, can we by a similar exchange of economic data and experiences help both young engineers and ourselves in necessary economic adjustments?

12. The criticism is raised that the young engineer lacks cultural training. Would it be wise to follow the example of other professions and make the study of engineering a graduate course?

13. The best man is not always chosen for a given job, any more than the best design is always used for a particular structure. The problem of personality and salesmanship is an essential factor. Most of us learned through hard knocks how to sell our services. Can we help the young engineer to develop necessary traits of personality? Can we set up a more comprehensive employment service not only to help the unemployed but to secure deserved advancement of the employed through a knowledge of new opportunities?

14. "Progress in the engineering profession depends upon the ability, technical skill, and personality of the individual," said President Riggs at the Fall Meeting in Rochester, in October 1938. A synonym for personality is character. As members of a society we develop individual ability and technical skill through the interchange of ideas. The third and most important factor, which can be developed only through association with superiors, we regard as intangible and leave to chance. Do we engineers need to cultivate more of that which the doctors call "bedside manner" and the lawyers term "court appearance"? Is not that the "it" which sells engineering and commands public recognition, and if so should we not help the young engineer to develop "it" early?

15. The young engineer knows full well the competition he must meet, and that he must be able to fight his way right up to the top. All he seeks is the right to do so on an equal basis. Is there any danger that in trying to help him ride smoothly over the economic bumps, we may make him soft, and dull his sense of initiative and perseverance?

The answers to these questions are no more settled in my own mind than they probably are in yours. Even if we knew all the answers, there is no assurance that we can put them in practice in a competitive system. However, I believe that a careful consideration of these questions will help to clarify some hazy ideas and will tend to make us all better men and better engineers. We will be doing an essential public service in that we are trying to improve human relationships, as well as physical conditions, under which people must live and work.

Forecasting Stream Flow from Snow Surveys

Methods for Predicting Total Quantity and Daily Distribution of Flow Over Critical Periods

A PAPER FROM THE 1938 WATER CONSERVATION CONFERENCE IN SALT LAKE CITY

By GEORGE D. CLYDE

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STREAM-flow forecasts do not provide more water, but they do make possible a more efficient utilization of the available supply. Made sufficiently far in advance, they form the basis for the annual planting program of the irrigator, the generating program of the power company, and the flood protection program of the entire watershed. On the snow-fed streams of the West, reasonable accuracy in 6-month forecasts is regularly being secured by the "percentage method" of interpreting snow survey data, and definite success in predicting the daily distribution of stream flow over considerable periods has also been achieved in a number of instances. Both types of forecast are discussed by Dean Clyde in the accompanying article.

AGRICULTURE in the United States west of the 100th meridian is dependent on irrigation, and the entire economic and social structure is built upon the adequacy and reliability of the water supply. A knowledge of the probable supply in advance of its occurrence is of great value in water conservation, both in making possible the most complete utilization of the water when it comes, and in enabling the development of control measures to prevent or reduce flood ravages. The water supply available for irrigation is derived largely from the high watersheds, on which the major part of the precipitation falls as snow. In Utah, for example, approximately 80 per cent of the runoff for April-September, inclusive, is derived from snow on high watersheds that constitute only about 20 per cent of the state's area. Practically all the streams in Utah may be classed as snow fed, and this is largely true of streams throughout the western United States.

Storage of water in the form of snow makes possible an advance determination of the probable water supply. Forecasts may be expressed in terms of acre-feet for specific periods, or in terms of discharge in cubic feet per second for specific dates. Forecasting the total supply over a given period, on the basis of snow surveys, is now well established, but a determination of the probable discharge for any specific date during the critical runoff season is more difficult. On streams having ample surface storage, a seasonal forecast is all that is necessary. However, where the water cannot be stored, but must be used as it comes, it is extremely valuable to know the time of its occurrence.

Snow surveying for stream-flow forecasting is not predicated upon a determination of the quantity of water on the watershed at the end of the precipitation season and the quantitative amount of the losses. Rather it assumes that a normal snow cover will produce a normal runoff. This has sometimes been called the percentage method of forecasting, and was developed and first used by Dr. J. E. Church of the University of Nevada.

Stream-flow forecasting based upon the percentage method assumes that precipitation is the most important factor and that losses can be grouped together and given a fixed value depending upon the particular watershed. For this assumption to be true, the major portion of the flow to be forecasted must come from high elevations where there is little or no winter melting, and the measurements of snow cover must be made in this area. For forecasts of early runoff, which comes largely from the lower areas, measurements of snow cover, spring precipitation, and soil moisture must be made in these areas. Every watershed seems to be a law unto itself and the snow-cover–runoff relationship must be worked out for each. Once the basic relationship and the effect of the modifying factors for a particular stream have been determined, a measurement of snow cover at the end of the precipitation season will indicate the probable water supply during the following summer months. The period for which the forecast is made will vary on different streams. In Utah it is made for the periods April-September and July-September, both inclusive.

Snow courses should be located above the line of winter melting, although there should be a few courses at lower elevations to furnish a check on winter and early spring melting conditions. Low courses are particularly desirable when a forecast of the April-September runoff is required. A satisfactory site is one having a uniform snow cover and fairly well protected from drifting winds. The course should be as free as possible from large irregularities, steep slopes, boulders, fallen trees, meandering streams, logs, brush, and snow slides. If a ridge location is necessary, the course should extend down both sides of the ridge.

In general, the length of the course should not be less than 500 ft nor more than 5,000 ft. It need not be straight, but can angle in any direction to avoid obstructions or other difficulties. The points of observation are located by tape measurement from the starting point, or from fixed markers along the line, and it is highly important that the observations be made at the same point each year. Snow samples are taken and water content determined at each observation point.

Following Dr. Church's pioneer work in forecasting flows from snow surveys, the Utah Agricultural Experiment Station became actively

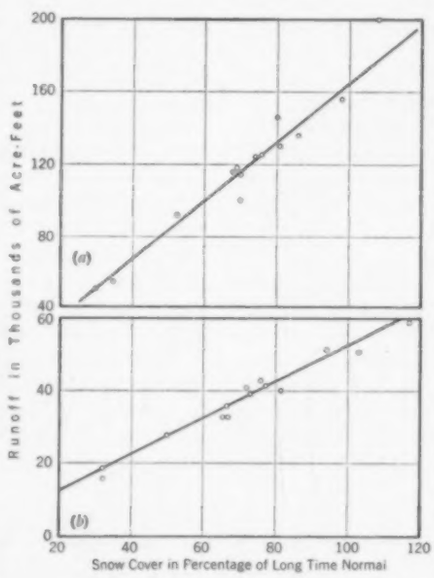

FIG. 1. RELATION BETWEEN SNOW COVER AND RUNOFF, LOGAN RIVER

(*a*) For the Period April-September, Inclusive

(*b*) For the Period July-September, Inclusive

interested in the subject in 1923, and in 1930 active cooperation with the Forest Service, the Weather Bureau, and the Utah State Engineer was developed. By 1935 the activity had grown to such an extent that coordination of the efforts of the various states became necessary, and the Bureau of Agricultural Engineering, U. S.

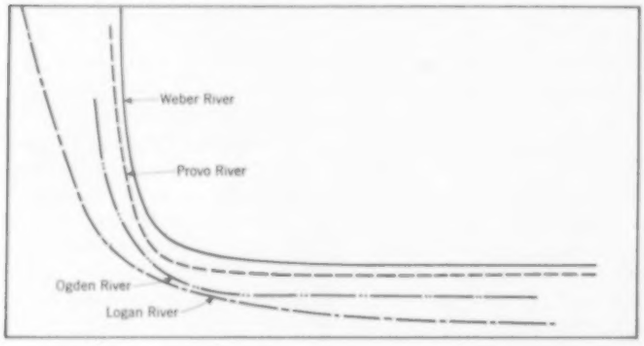

FIG. 2. CURVES FOR DAILY FORECASTS, FOUR UTAH STREAMS

Department of Agriculture, became an important cooperator.

In Utah the cooperative snow surveys now cover 85 courses, most of them above 8,000 ft in elevation. In addition there are more than 500 similar courses being surveyed in the other western states as a result of cooperation between the states and federal agencies under the general direction of the Bureau of Agricultural Engineering.

Snow-cover–runoff relationships are different on each watershed. In some instances one course well located furnishes the key to the probable water supply; in others, several courses are necessary. In Utah a large number of courses were established so that a true picture of conditions could be obtained. If after a few years of records are available it is found possible to drop certain courses without effecting the results, this can be done without a loss of time. On several Utah streams it has already been found that a simple relation exists between snow cover and runoff. Such a relationship is shown in Fig. 1, for two different periods on the Logan River. These are typical forecast curves. Forecasts are made for two periods—April-September and July-September. The first gives the total runoff during the irrigation season, and the second the runoff during the critical low-water portion of that season. Forecasts made regularly from these curves show a maximum variation of less than 10 per cent and an average variation of less than 5 per cent of the actual runoff. These limits of error are quite satisfactory.

FORECASTS HAVE BEEN PUT TO PRACTICAL USE

The utility of forecasts of probable total water supply has been amply demonstrated in Utah since 1923, when this work was begun. In 1926 the first water shortage occurred. No quantitative prediction was possible in that year, but the deficient snow cover did indicate that a shortage would develop. As a result, farmers in general reduced the acreage of their late-season crops. Those who did so matured what they planted, while those who did not found that much of their labor and seed were wasted. In 1931 another drought became evident before the beginning of the planting season. That year the sugar companies refused to contract for beets, and the banks to lend money on crops, until the water supply forecast was available. As a result of these precautions, most of the late-season crops that were planted were fully matured, and the effects of the drought materially reduced.

The drought of 1934 was anticipated from mid-winter snow surveys over the Utah network as early as February of that year. There was an extremely light accumulation of snow on the high watersheds and the earth mantle under the snow was dry. The lower watersheds were completely devoid of snow and the valleys had experienced only light precipitation. This early warning was emphasized by deficient precipitation during February and March, and by the first of April snow surveys clearly indicated that Utah faced the worst drought in her history. At that time the potential water supply did not exceed 35 per cent of normal. This condition was brought to the attention of the Governor of Utah on April 1, and he immediately set in motion the machinery necessary to meet the situation, by calling the first drought conference in history to be held before the drought occurred. At this conference two lines of action were developed—first, to put into effect immediately a water conservation program, and second, to begin immediately the development of supplementary supplies so that they might be available by the time the crops needed the water.

The conservation program involved an educational campaign to acquaint water users with the situation, and the modification of acreage planted, methods of irrigation, and administration of water to secure a maximum use of the available supply. Surprisingly enough, the water users of the state were in the main unaware of the seriousness of the situation. As soon as they were convinced, however, that a real shortage existed, they initiated a program to combat the drought. They did not wait until the drought was upon them before beginning operations, and as a result they matured most of the crops they planted, saved their orchards and perennial plantings, moved their livestock out of the state before they starved, and developed supplementary water supplies for irrigation and domestic purposes before the ordinary sources of supply dried up.

The water development program inaugurated upon the issuance of the water supply forecast enabled the state to develop, in time for use in saving crops, approximately 400,000 acre-ft of water. Estimates indicate a saving in Utah, in crops alone, due to the program of water conservation and the development of supplemental water supplies, of over $5,000,000. In addition to this, the saving in livestock effected through the federal purchase plan was of course tremendous.

PREDICTING THE DISTRIBUTION OF FLOW

A knowledge solely of the total quantity of water available during an irrigation season is not sufficient on those streams which are not fully controlled by artificial storage, because the forecasts of total supply do not indicate when the runoff will occur. Most of the diversions in Utah are from natural flow, and it is extremely difficult to divide the water among the users in proportion to their right when the rate of fall of the stream is unknown.

Rotation among users in each canal system is the universal practice in Utah, continuous deliveries being made to the different companies from the streams which supply the water. On a stream which falls rapidly during the summer season the user who gets his turn early gets more water than later users, for most deliveries are made in terms of a stream for so many hours, and though the streams decrease in size as the river flow diminishes, the time remains the same.

If it were possible to predict the discharge for any day it would be possible for the water commissioner to deliver water in terms of acre-feet, and the water master in turn to deliver water to users in terms of acre-feet per month. This would make possible a "rotation-on-demand" sys-

tem of deliveries that would greatly increase the efficiency of water use.

A study of typical Utah streams not regulated by storage reveals a striking uniformity in the slope of their daily hydrographs during the falling stage and the critical low-water period (July-September, inclusive). The Logan, Ogden, Weber, and Provo rivers have been used in this analysis. All these streams have relatively long records, but only those years subsequent to 1920 have been considered because this period includes years of maximum, minimum, and mean flow, and the average of this period is very near that of the entire period of record.

From an examination of the daily hydrographs it was found that after the river discharge had reached a maximum (shortly before the final disappearance of snow from the watershed), it declined sharply. In every case the decline appeared to follow a definite law regardless of whether the year was one of high or low flow.

To check this observation all the years of record used on each stream were arranged in four groups of different discharge ranges. It was seen from inspection that the curves formed by the falling portion of the hydrographs were similar in many respects. Further examination made by superimposing the hydrographs upon one another by means of a tracing table showed that if the bases of the hydrographs were made coincident, the curves were nearly parallel to one another. This parallel relationship covered the period beginning with the downward trend of the hydrograph and continuing on into the winter months. Thus it appeared that the slope of the hydrographs followed a rather definite relationship. The hydrographs were then shifted both horizontally and vertically, until they coincided, care being taken to keep the bases of the individual hydrographs parallel to one another. With the hydrographs in this position, a smooth curve was drawn through them which had the same shape as the mean hydrograph of the group. The variation of individual hydrographs from the mean curve was very small.

The same procedure applied to each of the four groups on each stream produced results that were equally well defined. The group mean curves on each stream were then superimposed on each other, keeping the bases parallel, and were found to be nearly coincident. A final "forecast" curve, representing the mean of the four groups, was then drawn for each stream (Fig. 2).

It was found that rectangular hyperbolas could be drawn that would coincide almost perfectly with the forecast curves, but to keep their axes parallel to the axes of the hydrograph it was necessary to rotate them through a small angle. In addition, a constant had to be added to the equation to compensate for the vertical shifting necessary to bring the hydrographs into coincidence. The result was a forecast equation of the form, $y^2 + Axy - x^2 = B \pm C$, in which y is the discharge in cu ft per sec at any date, and x is the time interval in days between date of forecast and date for which discharge is desired. A and B are fixed by the origin and rotation of hyperbola, and C is determined by the distance above

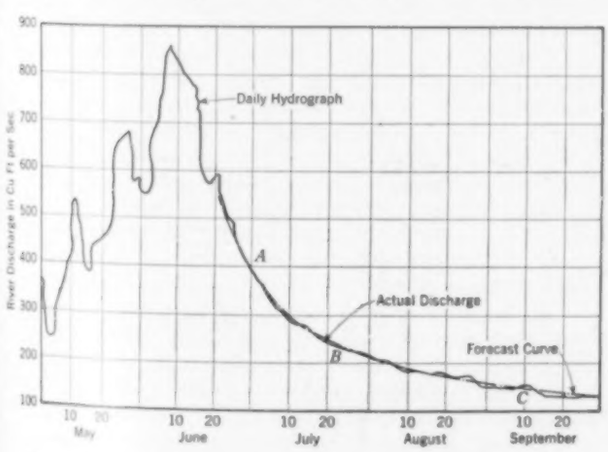

FIG. 3. DAILY DISCHARGE FORECAST, LOGAN RIVER, 1935

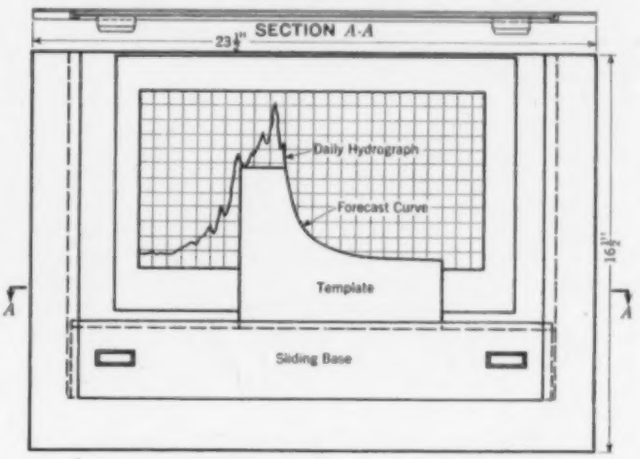

FIG. 4. BOARD AND TEMPLATE TO FACILITATE GRAPHICAL FORECASTING

or below the base of the hydrograph that the base of the hyperbola was found to be. The equation being a little awkward to handle, a graphical method of forecasting was worked out that would produce the same results.

GRAPHICAL METHOD OF PREDICTING DAILY DISCHARGE

Consider a daily hydrograph AB (Fig. 3) which represents the discharge of a stream for several days previous to the date on which the forecast is being made. The point B represents the last day of record available, and it is desired to forecast the stream flow for the remainder of the water year (to October 1). The forecast curve, curve ABC (dotted) is now superimposed on the hydrograph so that the slope of the curve at point A coincides with the slope of the hydrograph at point A, and the base of the curve is parallel to the base of the hydrograph. The portion of the forecast curve ABC then represents the discharge during that period measured from the base of the hydrograph.

To facilitate making the forecasts, a drawing board has been constructed (Fig. 4) which has an adjustable base with a groove in its edge so that a templet of the forecast curve can be moved horizontally and vertically and yet remain in proper position with respect to the known portion of the hydrograph. The latter is fastened to the board itself.

Forecasts of daily discharge from snow-fed streams, during the spring recession and summer low-water periods, can be made if the flow characteristics are known and the results are well within the limits of accuracy required for application to practical use. The forecasts can be made far enough ahead of the stream-flow occurrence to be used as a basis for distribution of water under the demand system.

Water supply forecasts do not provide more water, nor do they prevent or reduce natural water losses; but a knowledge of the extent and distribution of the supply in advance of its occurrence does make possible a more efficient utilization and is therefore an important factor in any water conservation program.

Residential Zoning Problems in New York City

Present Regulations Not Only Are Too Complicated But Have Little Relation to Practical Needs

By LAWRENCE M. ORTON

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THOUGH New York was the pioneer in city zoning in this country, its present regulations, says Mr. Orton, are sorely in need of revision. Well over four million people, he points out, or 60 per cent of the city's population, live in areas zoned as non-residential, and thus are excluded from the benefits that zoning should give. He outlines the main phases of the problem and suggests needed changes. In view of the increased public agitation for a tightening of zoning restrictions in New York City, he takes an optimistic view for the future.

BEFORE considering the status of residential zoning in New York City let us review briefly what zoning is expected to do for a city, particularly its residential areas. Like other regulations under the police power, zoning is intended to contribute something to the health, safety, and general welfare of citizens. Zoning meets these tests by preventing incompatible uses, and by establishing minimum restrictions on the coverage and heights, that is to say, the bulk, of buildings, in the interest of obtaining the light, air, ventilation, and open space requisite to good living and working conditions.

Urban dwellers have been signally unable to protect themselves in these matters. Without zoning, they are vulnerable to the selfish actions of their neighbors, particularly the intrusion of incompatible uses and the shutting off of light and air by buildings of excessive bulk.

Zoning differs essentially from most other regulations in that it differentiates between different parts of the city, applying to each area the regulations appropriate to it. For this reason, zoning goes much further in serving the interests of the individual than any general law applicable throughout the city. At the same time it gives the city an instrument of great potentialities for controlling and directing its growth.

One of the great sources of loss in our growing American cities has been their instability. Designers of streets, sewers—in fact of practically all public improvements—have until now been pretty much in the dark as to the size and nature of the structure for which these facilities were being provided. Given a greater degree of predictability, that is, a substantially smaller range of variation in the use and intensity of land development, it should be possible to achieve substantial economies in providing all these services. If the rapid growth of many cities has to date made such predictions difficult, the era of stabilizing population we are now entering presents an altogether different picture. The time has come for a correspondingly stabilized city structure, and zoning is one of the ways to bring it about. Let us consider the adequacy and potentialities of New York's residential zoning from this enlarged viewpoint.

PIONEER ZONING REGULATIONS DEMAND RESTUDY

New York was the pioneer in this country so far as zoning is concerned. If it should appear in the subsequent discussion that the zoning of the city is something less than the effective instrument of social progress just described, this is in no wise intended to disparage the efforts of those who initiated it a generation ago. As pioneers in unexplored territory they did their work well. Many benefits growing out of the zoning of the city could be cited if that were the purpose of this paper.

But recognition of New York's contribution as a pioneer in zoning should not prevent us from viewing the present situation realistically, or blind us to the problems involved, or excuse us from taking action if drastic changes are called for.

My subject is limited strictly to New York City, but at the outset I wish to refute the idea that New York is a case by itself, and not typical of anything else in the country. There are many facts which deny this conclusion emphatically, so far as significant aspects of land use and zoning are concerned.

For example, some time ago Harland Bartholomew, M. Am. Soc. C.E., made a very useful study of the proportion of urban lands devoted to various uses, published as one of the research reports of the Harvard School of City Planning. It indicated that, on the average, the developed portions of cities contain about 10 per cent business and industrial land; 10 per cent parks and other open spaces; and 80 per cent residential use. Recent careful studies of New York City show that the percentages of the city's area in the first two categories are exactly the same as those given. Residential use now occupies about 60 per cent and the remaining 20 per cent is vacant land, which will doubtless go largely into residential use in the course of time.

These facts provide the first and most obvious basis for criticism of the present zoning. The areas zoned for the purposes just cited and the areas actually used for these purposes are substantially in reverse, non-residential uses being permitted in about 63 per cent of the city's area. Worse still, those portions of the city where the discrepancy between actual use and zoned use is greatest happen to be those in which most of the people live, so that well over 4,000,000, or 60 per cent of the population, live in areas now zoned as non-residential. In view of the benefits supposed to accrue to the people through residential zoning, what is to be said of a zoning law which excludes three-fifths of the city's population from such benefits? The first commentary upon the need for strengthening of zoning in New York's residential areas is therefore the rather obvious one that the places where people actually live should be zoned as residential. Until this is done no revision of the provisions governing residential areas will be of much avail.

But this is not all. The flight from reality typified by New York's zoning is further illustrated by the fact that, as in several other pioneer cities, three types of districts are set up, separately defined in the ordinance as "use," "height," and "area" districts, shown on three separate sets of maps.

Turning now to the height and area maps, let us see what they have to offer. In 1901 and again in 1928 the Legislature of the State of New York passed laws establishing minimum standards for the construction of multiple dwellings. These laws, unlike zoning, are equally applicable to residential buildings containing more than two families wherever they may be erected.

that is to say, their standards could be no more exacting than were practicable in the parts of the city where land values are highest and population densest; and I can assure you that many and regrettable compromises were necessary before the laws could be passed. Nevertheless, the standards of building bulk contained in the Multiple Dwelling Law are more restrictive than those in the zoning law in all of Manhattan except the very northernmost tip of the island, in the vast portion of downtown Brooklyn (as far out as Prospect Park), in the lower central and easterly portion of the Bronx, and in a considerable area in Long Island City, Astoria, and other nearby portions of Queens.

In other words, zoning might as well be non-existent so far as the residential buildings in these parts of the city are concerned. I need scarcely remind you that in these instances, too, the areas where zoning is not effective are those in which most of the people live. I do not have the exact figures, but if 60 per cent of the city's people live in non-residential areas, then a not far different proportion of the people live in those parts of the city in which zoning of the bulk of residential buildings is to all intents and purposes non-existent.

Finally, to complete the picture, it must be said that the outlying areas of the city, beyond the boundaries just described, are equally wide open in proportion to their potential use. The discrepancy between actual, potential, and zoned building bulk has often been stated in numerical terms somewhat as follows. Whereas the city has 7,000,000 people at present, and probably looks forward to about 9,000,000, the buildings that might now be erected in residential areas could accommodate about 75,000,000, and if we put into residential areas the incorrectly zoned non-residential districts, the number would be proportionately increased.

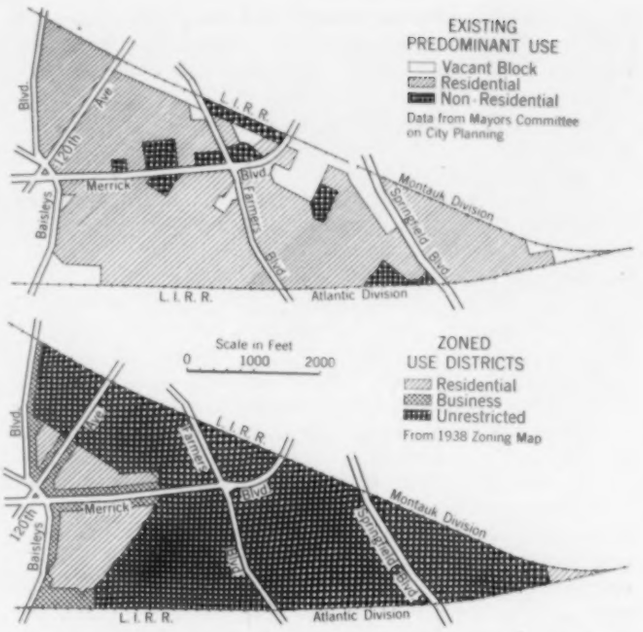
In other words, residential zoning for New York needs to be drastically revised if it is to have any significant relation whatever to the practical possibilities of land development and growth of the city. In this New York probably is reasonably typical of most cities.

Thus described, the strengthening of New York City's residential zoning appears to be a Herculean task. But there are many factors favorable to the successful accomplishment of this work at the present time. These include a generation of experience, both technical and legal. Public authorities and their advisers have experimented, discovering what sort of zoning works best, what the courts will uphold, and what they are not prepared to accept. In the course of all this, the frontiers of this sector of the police power have been pushed forward, and a body of supporting decisions has been built up. It is possible to proceed much further now than when New York was first zoned.

This improved outlook is not limited to the methods and legality of zoning itself. It extends to the whole background of fact and analysis as to the city itself, its existing conditions and future outlook. The several million dollars worth of research done in this city as a by-product of the depression, largely through work-relief projects, has placed us in position to proceed with far greater assurance than heretofore.

These technical aids are probably no more important than the psychological and political support growing out of increased public understanding of, not to say demand for, the protection which is to be found in zoning. Limited as our zoning has been to date, the people have found it good, and want more and better zoning.

Finally, not unrelated to this growing public sentiment, there is now a governmental set-up in New York City much better adapted to the handling of all city



DISCREPANCY BETWEEN THE ZONING CLASSIFICATIONS AND ACTUAL PREDOMINANT USE IS TYPIFIED BY THE SECTION OF QUEENS BOROUGH HERE SHOWN

planning matters, particularly zoning. I refer, of course, to the fact that the new city charter not only established a City Planning Commission but requires all matters affecting the city's development to pass through the Planning Department, thus obtaining a coordinated consideration of all these matters by a non-political body with a competent technical staff. The commission's determinations for the most part can be reversed only by a three-fourths vote of the Board of Estimate, so that there is a considerable presumption that the planning viewpoint will prevail.

There are naturally obstacles to any progress of this sort. We need not mention such old friends as inertia, but the outmoded structure of New York's present zoning, with its three separate maps and indirect and negative approach, is not to be dismissed lightly. False expectations as to land values and building possibilities, perhaps generated or augmented by over-liberal zoning, must also be counted among the psychological obstacles to be overcome in remedying the city's zoning defects.

The present favorable circumstances, so far as zoning revision is concerned, are to a considerable degree the result of a series of steps growing out of the actions of voluntary organizations. As long ago as September 1935, soon after the appointment of a semi-official Committee on City Planning by Mayor LaGuardia, the City Club addressed a communication to the city government asking for effective action in respect to zoning revision. Other organizations, including the Merchants Association and several of the professional business organizations, joined in the request. As a result, the late Bernard S. Deutsch, then chairman of the Planning Committee, appointed a special joint committee to investigate and report upon the matter. This committee worked hard and long, devising a formula by which excessive bulk of building might be prevented within the framework of the present ordinance. The time was not ripe for its presentation, but the Mayor's committee and its staff devoted considerable additional time and thought to the matter.

Meantime the voluntary Regional Plan Association, operating in the much larger territory of the metropolitan

area, gathered, and from time to time presented, argument and facts in support of thorough-going zoning revision. The Association's Information Bulletin published in October 1938 is devoted to this subject.

Nor was the inexorable trend of events including and growing out of the depression without its influence. As pyramided mythical land values disappeared, the competition for sounder values based upon the provision of better light, air, and open space has been intensified. Large-scale building operations have been undertaken by both government and private enterprise, and with them the advantage of drastically lower coverages has become apparent. In the large projects, coverages range between 20 and 30 per cent. The Federal Housing Administration, among other agencies, has frequently insisted upon higher zoning standards.

All these factors have resulted in a substantially modified outlook with respect to zoning. This is indicated by the matters presented to and acted upon by the new City Planning Commission in its first year. I have not attempted to analyze the figures exhaustively over any considerable period of time, but it is apparent that the number and extent of zoning changes made in 1938 is from two to several times those made in previous years. No less than 11,000 acres were affected by these changes. Certain large items still pending before the Commission suggest an even more rapid rate of change during 1939.

A development of a slightly different sort is the modification of the text of the zoning resolution itself. One such amendment adopted during the year established for the first time in New York City a strictly single-family house district. Our zoning pioneers hesitated to set up such a district explicitly, but with ample precedent and judicial support in other cities, we have now taken steps to see that single-family house communities may survive even in New York. But the most significant fact is the increase in the number and extent of petitions for changes involving a stiffening of restrictions, as compared to the very limited size and number of requests for relaxation of restrictions.

HOW CAN PRESENT DEFECTS BE REMEDIED?

Assuming it to be self-evident that the residential zoning of the city is defective, what should be done? How far can we expect to go in the direction of remedying the present defects? How shall we proceed to do it?

One or two steps are relatively simple. I have already indicated that one of the chief defects in New York City's residential zoning is that most of the people live in non-residential areas. This obviously is one that can be remedied by the simple expedient of adjusting district boundaries. All the information necessary to such adjustments is now in hand, so far as present uses are concerned.

But the real problem is in the nature of the restrictions themselves. The structure of New York's zoning is antiquated and unnecessarily complicated. No less than 25 combinations of height and area districts are found in the residential areas alone. It is pretty well agreed that in order to do a good job it will be necessary to replace the old law with some entirely new and up-to-date zoning provisions. In doing so not only should reasonable standards be provided for the individual building, and protection from exploitation by neighboring owners, but it should be possible to relate all future residential building to a comprehensive master plan for the whole city.

I am not at all sure that the answer is yet in sight. There are some fundamental obstacles. The first of these is economic. Let us not delude ourselves. Any such rationalization of city growth involves treading on someone's toes. During the period of rapid expansion speculation was rampant in New York City, as elsewhere. In future, under a more stable population outlook, the opportunity for speculation will greatly diminish. An effective zoning law is one means of recognizing and giving effect to this reduction in speculation. Its justification lies in the fact that if well done it affords the greatest good to the greatest number. But we must be prepared to face the fact that individuals will be adversely affected by it and will not like it.

The second obstacle is somewhat more technical. Zoning was primarily designed to afford the owner of a single lot protection against his neighbor. In order to do so, and in view of the type of building customarily constructed on single lots, especially in congested areas, it was thought necessary to employ extraordinarily complicated provisions and formulas. As anyone who has read the New York zoning law knows, it is full of complicated yard, court, and setback provisions relating to the property lines of the individual lot. It has become apparent that these zoning restrictions, based upon the relationship of individual lot lines, not only stand in the way of some very excellent building designs but in the final analysis have little or no relation to the virtues or defects of the large-scale projects, both private and governmental, which are entering more and more into the building picture nowadays.

The problem may be stated briefly as follows: How can we, at one and the same time, decrease the opportunities for overdevelopment of land, that is to say for excessive densities of population and building bulk, and at the same time liberalize our restrictions so as to permit the widest possible exercise of architectural genius, and obtain a maximum of benefit from the large-scale design of housing projects?

In New York previous to 1900, multiple dwellings were customarily built on lots of 25 ft or less in width. The Tenement House Law of 1901, through its court and other provisions, rendered it uneconomical to build apartments on lots less than 50 ft wide. The Multiple Dwelling Law, passed in 1928, again indirectly but effectively stepped up the lot size, so that for economic design apartments required at least 75 or 100 ft of frontage. In other words, the realities of the situation already exempt us from the too-detailed provisions that might be necessary to control buildings on very small lots. Doubtless further progress will carry us further in the same direction, so that future zoning regulations should be conceived in terms of buildings of considerable size and of groups of such buildings.

Our future zoning, therefore, should not only permit but encourage the better grouping of buildings, and then clear the way for all the advantages of concentrated open space, more useful recreation facilities, and the superior outlook which such grouping can provide.

One method of approaching the problem would be to recognize frankly the need for two different sets of regulations, depending upon the size and nature of the building operation. It may be necessary, for example, to retain fairly detailed provisions where but a single building is to be erected, but to include in the zoning law opportunity for escape from these provisions under circumstances justifying suspension of the detailed rules. In the latter case, the direct limitation of gross building bulk, coupled with suitable standards as to light and air, might be sufficient. Under such methods I can picture not only much greater freedom of design for the architect, but much greater advantages to the residents and to the whole community.

Autobiography of George H. Pegram—Part IV

By THE LATE GEORGE H. PEGRAM

PAST-PRESIDENT AND HONORARY MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

THIS, the concluding abstract of Mr. Pegram's autobiography, is a brief résumé of his most important work—that as chief engineer of the Manhattan Elevated Railway Company and, later, of the Interborough Rapid Transit Company. The autobiography, though written in 1933, ends with 1924. Mr. Pegram, however, remained in active connection with the Interborough Rapid Transit Company until his death in 1937. The complete biography, in manuscript form, has been deposited in the Engineering Societies Library.

ON February 1, 1898, I began my connection with the Manhattan Railway, which comprised all the elevated railroads in New York City. It was composed of four lines having an aggregate of 37 miles of structure, carrying 110 miles of single-track roads. The lines ran north and south on Ninth, Sixth, Third, and Second avenues, and several spurs made east-and-west connections.

The history of elevated roads in New York City is interesting. The Ninth Avenue line was opened in 1869 from Dey to 29th Street, the only stations being at the terminals. The structure consisted of long plate girders supported on columns made of two I-beams set in a cast-iron base and fanned out at the top for the support of the girders. There were no cross-ties, the rails being fastened directly to the girders. It was operated by endless cable with stationary engines at four streets. In 1871 trains of a "dummy" and three cars replaced cable operation, and other stations were progressively opened until 1876, when the road was reconstructed, double-tracked, and extended to 59th Street. (At that time truck gardens and squatters' shacks occupied almost all the land north of that point!)

From then on the other lines were gradually opened. These structures are today (1933) probably the oldest metal structures, in point of service, in the world. All of them were of riveted construction except the Sixth Avenue line, which was a pin-connected structure. The spans of the latter were generally 35-ft lengths of 5-panel trusses.

In early times generally all spans over 50 ft were pin-connected trusses, but for years the pin-connected truss for spans of less than 200 ft has been considered inferior to riveted construction which was generally adopted—a change no doubt brought about by the fact that there were few makers of eye-bars, whereas every bridge shop could do riveted work. The practical abandonment of pin-connected construction in bridges under 200 ft, with the attending sacrifice of economy, is not yet justified by experience in the use of our bridges, and especially that of the Sixth Avenue Elevated Road which, weighing only half as much per lineal foot of track as the riveted construction, is still (1933) in competition with it after 56 years of service.

Some time before I took up my duties with the Manhattan Railway, the use of electricity for street-car propulsion had made possible the adoption of tunnels for urban transportation, and in 1894 a state commission had been established for the purpose of building rapid transit lines. This commission also had the power to grant franchises for extensions of existing elevated roads.

In order to avoid competition with a proposed city subway, Mr. George Gould (who had succeeded his father to the presidency of the Manhattan Elevated Railway) instructed me to prepare plans for extensions of the elevated lines. But these were rejected by the Rapid Transit Commission, and the only alternative was for the Manhattan Railway to participate in the construction of the subway. I was instructed to look into the matter through conferences with the late William Barclay Parsons, Hon. M. Am. Soc. C.E., who was chief engineer of the commission. I went over the proposed subway lines with Mr. Parsons, and while traversing the goat pastures north of 86th Street I was not impressed with the financial prospects of the new subway. I now realize that it was ignorance of the possibilities of New York that deceived me.

It was not as difficult as I had imagined to make friends with New York engineers, as most of them were members of the Society, to which I had belonged since 1880. I joined the Engineers Club of New York in 1899. At one of their dinners I happened to get at a table of jolly fellows—among them, the late Charles Warren Hunt, Secretary of the Society. As the dinner wore on and the party "got gay," Dr. Hunt told of the cups he had won at golf. Getting into the spirit of things, I challenged him to an eighteen-hole game, the loser to pay for a dinner for the party at the table. He accepted.

THE HAZARDS OF GOLF

The match eventually took place at the Montclair Club. Dr. Hunt arrived dressed in his field regalia and with a big bag of clubs. I was in everyday dress with no clubs or other impedimenta. Hunt asked, "Where are your clubs?" I replied, "I have no clubs, and what's more I never played a game of golf and have never even seen one played." The effect of this declaration on the company was electric—except in Hunt's case, where it was decidedly thermal. After raising the already high temperature of the air, Hunt asked, "How are you going to play without any clubs?" I replied that I could use his. He replied: "Not if I know myself." The deadlock was finally broken by one of the group, who offered to lend me his daughter's clubs; and our "seconds" agreed that Hunt was to allow me one stroke a hole on the first nine and two strokes a hole on the second nine. When we started to play, I found that the girl's driver was entirely too short and I induced Dr. Hunt to lend me his driver for "just one shot." I took a swipe, and the head of the driver broke off and went sailing after the ball. Then Dr. Hunt exploded and divulged the secret of his former successes. It was all in the magic driver that I had broken! At the end of the eighteenth hole our scores were tied, and we played the nineteenth hole which Hunt won.

As winner, Dr. Hunt claimed the right to specify the details of the dinner and chose a dinner at Coney Island, after which we did the various stunt sports. The affair was such a success that it became the custom for each of the party in turn to lose a foolish bet and give a dinner, the details of which were arranged by a committee, the loser having nothing to do but pay the bills.

A new development in electrical traction, the invention of the multiple-unit system by Frank J. Sprague, was of

special advantage in the electrification of the Manhattan elevated road. A five-car train was the limit with a locomotive on account of risk to the structure, but with the weight of the motive power distributed, trains of any length could be operated without damage. In 1899, this system was being used successfully on one of the trains on the South Side Elevated in Chicago. There the controller operated by the motorman at the head of the

THE SIXTH AVENUE ELEVATED—1879–1939
This Venerable Structure, Part of the System of Which Mr. Pegram Was Once Chief Engineer, Is Now Being Razed to Make Way for a New Subway

train operated similar controllers on the several cars through an electric train line. In the method finally adopted, these similar controllers were replaced by a series of contact boxes by which the same result was achieved.

My special duties in connection with the electrification included the design of the power house at 74th Street and the East River, and the seven substations located at proper points on the lines where the 11,000-volt alternating current generated at the power station was transformed to 600-volt direct current and fed to the third rails along the tracks. I thus had the honor of designing the largest power house in the world.

We anticipated the great relief of the traveling public when electric operation should begin. No longer would there be intolerable congestion during rush hours, with trains bunched for a mile in length waiting to pass key stations. Besides, the public would be transported at twice the usual speed. We had justly gotten ourselves into a mood to receive bouquets when the great event took place—on December 29, 1901. But immediately afterwards a sleet storm occurred, and the ice coating on the third rails nearly stopped the trains. So instead of bouquets, only curses were showered on us. The danger from ice was subsequently overcome, but by that time the bouquets were forgotten.

PROBLEMS IN TUNNEL CONSTRUCTION

On January 1, 1903, the Interborough Rapid Transit Company leased the Manhattan Railway Company for ninety-nine years. I continued as chief engineer of the Manhattan until June 1905 when, following the resignation of S. F. Deyo, M. Am. Soc. C.E., I was appointed chief engineer of the Interborough and of the Rapid Transit Subway Construction Company, the latter company building the subway which the Interborough Company operated. Soon afterwards I was called to the office of August Belmont, the great banker (who was president of both companies), to discuss the subway tunnel under the East River at the Battery. The portions of the tunnel so far built, he said, were in very bad shape—due, the contractor claimed, to the weakness of the design prepared by the Public Service Commission.

The next day, at Mr. Belmont's request, I went through the tunnel. The Brooklyn portion had progressed about halfway through the slip at the foot of Joralemon Street. The cast-iron tube was irregular in grade and flattened in places so that it would have to be reconstructed to permit a car to pass through. There were numerous cracks and many broken plates in the cast-iron ring. In several places the roof was temporarily supported with wooden posts. I was inclined toward throwing the contractor out and getting another one, but eventually it was decided that I should undertake the direction of the contractor's work instead. In this the contractor acquiesced, since we had to pay the bills.

It was apparent that the vertical height of the tube must be restored and the grade straightened. One of the experts proposed freezing the ground around the tubes so that in a ring of frozen ground we could enlarge and replace the tubes at places. We tried this, and it resulted in a dismal failure, because frozen ground is such a bad conductor that only a thin ring could be frozen. I finally decided to restore the tube by replacing bottom plates under air pressure and both top and bottom plates above high water where air was not required, and this was successfully done. The material through which the tunnel was driven was quicksand, and so finely pulverized that wherever water leaked into the tube, the sand came with it. If a plug was taken out of the tube in the portion not under air pressure, a stream of sand and water would squirt across the tube and the tube could be moved up or down or sideways by "bleeding." I attempted to correct the alignment in this way, but it took so long that I gave it up.

All tunnels leak, even after calking, and it was apparent that in this tunnel the operation of trains would augment the leakage to such an extent that settlement would be sure to occur. Such an eventuality could not be risked, so I decided to support the tunnel through the quicksand portion on reinforced concrete piles driven to bedrock. This was accomplished by temporarily taking out the lowest third of a cast-iron ring of the tube at intervals and sinking two piles. To sink piles within the tubes required that they be made of 5-ft sections, one fitting over the other as driven. These sections were 20-in. steel pipes sunk by the water-jet method and pressed down by jacks reacting against the roof of the tunnel. After reaching hard bottom the cylinders were filled with concrete reinforced with steel rods, which were bent over at the top to join with a concrete cradle on which the cast plates of the ring were replaced. Some of these piles extended 80 ft below the tunnel.

While we were constructing the tunnel, the contractor, in order to prove the design too weak and thus support his claim for additional compensation, was arousing extensive scare propaganda. New York and Brooklyn papers frequently published articles condemning the tunnel as practically wrecked and bound to prove unsafe for use if ever finished. But the final coup of our contractor finished him. He came to Mr. Belmont with a report by three of the most prominent engineers in New York to the effect that if the tunnel did not collapse when the air pressure was removed, the first train would certainly destroy it. He threatened to publish this report unless Mr. Belmont made a certain settlement with him. Mr. Belmont sent for me, and I advised him to let the contractor publish the report. "If it is true," I said, "it can't make your condition any worse, and if it is not true, it will destroy the enemy. I know that it can't be true because I am in the tunnel every day and know that it has proper strength."

I took the report home that evening and found a mistake in the calculations accompanying it which, when corrected, showed the tunnel to be twelve times as strong as the report claimed. However, the effect of such public criticism drives one to extreme measures often unnecessary, and I determined to make the tubes doubly strong by applying a reinforced concrete lining throughout their length.

Operation began January 1, 1908, and after twenty-five years this tunnel—the first completed under the river at New York—is apparently in as good condition as when first opened.

The first subway extended from the Battery up Broadway and Fourth Avenue, across 42d Street west to Broadway and thence north to 242d Street, with a branch from 96th Street northeastward to 180th Street and Boston Road. After its initial operation in 1904, traffic so increased that it became apparent that its capacity limit would probably be reached in ten years. Steps were soon taken for an enlargement of the system.

The Interborough Company and the Metropolitan Street Railway Company were rivals for possession of the new subways. The Interborough claims were based upon the advantages to the public in having them operated in connection with the existing subways, and the Metropolitan claimed that subways could be operated in connection with the street car lines. These opposed interests soon combined, forming the Interborough Metropolitan Company.

This city then took the position that it would build a triborough system which could be operated independently, and it built the portion of the Lexington Avenue subway from 110th Street to 53d Street and from 42d Street to 38th Street—the latter portion being abandoned when connection was made with the existing subway at 42d Street.

On June 18, 1910, a contract was made between the city and the Interborough Rapid Transit Company for the construction and operation of the lines in the boroughs of Manhattan, Bronx, Queens, and part of Brooklyn, with the result that we were ultimately leasing and operating a system of 76 miles of structure with 265 miles of single track.

The Public Service Commission, acting for the city, prepared the plans for the extensions, let the contracts, and supervised the work. The Interborough Company felt that in order to provide for the continuous operation of its trains and the safety of its passengers, it should construct the new sections where connections were to be made with the existing subway, and decided to bid for the construction of such sections through its subsidiary, the Rapid Transit Subway Construction Company, of which I was chief engineer.

The four sections were exceptionally difficult to construct, the one at Grand Central being in my opinion the most difficult piece of construction in the world. At this junction there were four levels of traffic to be provided for, and all while trains were constantly running.

For resident engineer on the extremely difficult work in the vicinity of Grand Central, I appointed my old friend, the late Robert A. Shailer, who was generally regarded as a great expert in tunnel construction. Mr. Shailer brought to the job as general foreman John McCormick, who had worked up from laborer under him and who was the most remarkable man I ever saw on construction work. McCormick was a good mechanic, but best of all was his courage, without which this difficult job probably could not have been done with safety.

I recall on occasion when I was going through the work with him (I say through, because it was through passages and holes). "Mack," I said, "this is extremely dangerous work." "Yes," he replied, "but it has to be done. Isn't that the answer?"

Once a large city water main broke at 42d Street near Park Avenue, and water flowed through the excavation for the subway down into the completed Queensboro tunnel faster than the pumps could remove it. These pumps were located at the sump at the lowest part of the tunnel, where they were enclosed in a concrete chamber between the tracks, the opening to the chamber being from the track level. As long as we could hear the regular exhaust of the pumps we were assured that the tunnel would finally be pumped out. But the pump stopped, and the Interborough men fled. In this emergency I called on McCormick, although the pump was in a completed tunnel with which he had no connection or responsibility. He and I went down the bench-walk along the track, which is 4 ft above the track level and over which the water was flowing in the region of the pump. Taking a bottle of alcohol, with which he had supplied himself, he plunged below the water and entered the pump room through the submerged door. Presently the exhaust of the pump was heard again, and the day was saved. Ice, formed by the expansion of the air at exhaust, had stopped the valve, which when cleared with alcohol began to function again.

During the war, construction proceeded slowly because of the difficulty of securing labor and materials. In fact, the effect of the war was to extend the time required to do the work by about 50 per cent, but it was finally completed.

It was evident that the express service on the new subway would seriously affect the traffic of the Manhattan Elevated Railway unless something was done to improve the express service on those lines. For some distance near each end of the elevated lines, express trains ran on the local tracks, thus reducing the road to two-track capacity. If, however, one express track could be continued independently to the end of each line, it would give the capacity of a four-track road in the direction of rush hour traffic, although having but three tracks. "Third-tracking" was accordingly adopted, and it devolved upon my office to prepare drawings, make the design, and do all work in connection with this project. The work was done in less than two years (1914–1915) without accident or the interruption of traffic.

"THE KAISER WAS A LOAFER"

At the same time we were authorized to extend the elevated roads, and did so in the same two years at a cost of $14,000,000. This work was going on at the same time that I was in charge of the subway construction, and to make my leisure still less abundant I served from 1912 to 1924 as chief engineer of the street car lines of the old Metropolitan System, renamed the New York Railways. The Kaiser was a busy man during the war, but I used to regard him as a loafer compared to me.

Satisfying and sometimes thrilling as construction work is, it pales before that calmer and not less satisfying experience that one gets from association with his fellows in pursuit of the common interests of his profession. It is a great mistake in life to neglect close association with those in a similar calling. I was fortunate in being inducted early into this sphere of life, being elected a Junior in the Society in 1880 and Member in 1883. I have taken a deep interest in the Society from the start, and my intimate friends have always been among its members. It has been a means of social and business contact with engineers of railways, industries, and business organizations with whom I have had to deal.

Reports of Technical Division Committees

As Presented at the 1939 Annual Meeting of the Society

Committee on Flame-Cutting of Structural Steel

THE ULTIMATE objective of the Committee on Flame-Cutting of Structural Steel is the preparation of a specification that will indicate under what conditions flame-cutting may be used without the necessity of subsequently planing the flame-cut edges.

Five years ago the first activity projected was a survey of the literature on flame-cutting. A second requirement was expected to be the making of a fairly extensive series of tests. Fortunately the Committee has been largely relieved of both these obligations, since they have been executed by bodies outside the Society. Through the courtesy of the Welding Research Committee, sponsored by the Engineering Foundation, advance copies of its comprehensive survey of the literature were placed at our disposal. This survey discloses the fact that so large a number of tests have already been made, both here and in Europe, on the effects of flame-cutting structural grades of steel, that very few, if any, additional tests seem to be necessary.

Under these gratifying conditions the Committee considers that its task is no longer one of research, but has become primarily one of interpretation. The available test results have been reported in terms of metallurgical criteria, such as carbon content and Brinell hardness numbers. Such criteria are, of course, unsuited to practical application in a fabricating shop. Therefore the immediate aim of the Committee will be the translation of these criteria into simple rules whose execution will not interfere unduly with shop practice.

While no formal vote of the entire committee has yet been taken, the consensus of the members appears to indicate:

1. Ordinary grades of structural steel, such as A.S.T.M. Specifications A-7 and A-9, may be flame-cut without other heat treatment.
2. In flame-cutting most of the low-alloy structural grades, such as silicon steel, manganese steel, and nickel steel, either pre-heating or post-heating is necessary for strained members.
3. The beneficial effect of mechanically guiding the cutting torch is realized by all, but the Committee is not yet in entire agreement as to when this method should be made obligatory. Its requirement appears to be linked up with questions as to whether or not the member is to be subjected to major stress, the radius of reentrant curves, and the kind of service for which the member is intended.

F. T. LLEWELLYN, *Chairman*

Committee on Structural Alloys

SHORTLY AFTER the formation of the Committee on Structural Alloys, several meetings were held. It was decided that before any definite advanced program was developed the Committee ought to make a thorough survey of the status of high-strength steels to date, in order to present a picture of the lines of development that were going on in foreign as well as American practice, in attempts to secure suitable high-strength steel for major structures. This survey, developed by various members of the Committee, was summarized by a report in PROCEEDINGS for March 1936.

The result of this work brought out several interesting facts:

1. Certain types of steels had been tried and found wanting either from the economics of their manufacture and fabrication, or because the suggested type was too variable in nature to be considered a standard steel.
2. There was no uniform trend to any particular type of analysis for steels, as produced either in America or in foreign countries, and it was apparent that the world over, the steel mills and structural engineers were seeking and attempting to secure a high-strength steel of economic first cost and satisfactory physical characteristics.
3. There seemed to be, as far as published literature indicated, very little information on the physical characteristics of these steels other than straight tension or bend test data. Knowledge of fatigue, corrosion fatigue, and impact tests, in fact tests that would permit complete evaluation of the merits of the various types proposed, was apparently non-existent.

In other words, there were various steel types proposed and being used, but there were few definite data on their value, and no method of testing had been developed that would permit comparative evaluation of these steels and enable an engineer to judge correctly of their practical merit. In fact, there was some indication (except from the purely tension-value standpoint) that some high-strength steels had shortcomings in physical properties that indicated they might be inferior to, or at least no better than, plain carbon structural steel when subjected to localized stress conditions; that is, they lacked a certain quality of ductility that would permit metal flow and relief of highly localized stress concentrations without impairment of the life of the structure they were used in. At least some of these higher-strength steels seemed to lack the fool-proofness of ordinary carbon structural steel.

Realization of these facts led, in our Committee meetings, to discussions of steel types and methods of procedure in evaluating their merits. There resulted a somewhat general feeling within the Committee that considerable experimental work would be required as ground work if we hoped to find means of assuring the profession that satisfactory types of steel could be produced, and that such experimental work would have to be done before the Committee could make any general recommendations as to steel types for the Society's consideration.

At this stage of the Committee's deliberations, Wilbur M. Wilson, M. Am. Soc. C.E., of the University of Illinois, made available to us the results of a rather extended series of fatigue studies on riveted joints that he had been conducting for the San Francisco–Oakland Bay Bridge Commission in conjunction with several of the steel fabricators.

The results obtained by Professor Wilson are, to say the least, thought-provoking. These test results indicated that such high-strength steels as the silico-manganese type now considerably used in major structures, and nickel structural steels, irrespective of the fact that they possesssed higher tensile properties, were not better

in fatigue resistance when tested in a testing machine in the form of riveted joints than our plain low-carbon structural steels—a confirmation of the fact that many of these higher-strength steels may lack that intrinsic ductility required to relieve local over-strains.

Professor Wilson's preliminary studies explicitly point out the necessity of continued investigational work if we hope to find a really satisfactory high-strength steel for our future major structures. Such work cannot, however, be carried out without funds, and as the Committee today is not in a position to inaugurate such studies, it must remain a sort of committee-of-review of work accomplished by others until such time as funds are made available to enable it to proceed with a program of its own initiation.

ROBERT S. JOHNSTON, *Chairman*

Committee on Sewage Treatment Costs

THE Committee of the Sanitary Engineering Division on Sewage Treatment Costs has little progress to report—in part because of the demands on the time of the members by the current PWA program and other activities, and in part because of the magnitude of the project and the variety of factors which enter into the problem. Nevertheless, an effort has been made to determine the proper scope to be covered by the work of the Committee.

Two possibilities as to the scope of work have been suggested: (1) that the Committee should cover the broad field of the economics of sewage disposal, including costs of various sewage treatment procedures related to accomplishments; (2) that the Committee should cover the assembling of cost data, and the preparation of standardized forms for recording cost data, both construction and operation.

The Committee members favor activities in line with the first or broader scope. Accordingly, an outline has been prepared indicating some of the factors relating to, and affecting sewage treatment plant costs. These special factors have been grouped under four major divisions, as follows: (1) objectives and extent of sewage treatment, (2) sewage quantities and characteristics, (3) sewage treatment plant loadings, and (4) cost considerations.

The urgency with which many recent sewage disposal projects have been developed, and the efforts required to meet the various regulations imposed by federal aid have precluded as extended consideration as would normally be given to the relative merit and comparative costs of alternate project possibilities or the fundamental economics of the projects.

It would seem desirable, during the present period of unusual activity in the construction of sewage treatment plants, that an effort be made to record in comparable form the construction costs for a number of projects in various parts of the country. Sufficient data should be obtained to establish within reasonable limits the comparative construction costs for various types of plants and for various plant elements. Also some standard form for reporting operating costs would aid plant operators and public officials to report operating costs in a form that could be compared with similar data from other communities.

Comments or suggestions that would aid the Committee in its work would be heartily welcomed.

WILLIAM E. STANLEY, *Chairman*

R. A. ALLTON — GEORGE J. SCHROEPFER
PAUL HANSEN — A. H. WIETERS

Other Committees

Reports of the following committees have already appeared in CIVIL ENGINEERING: Committee on Technical Aspects of Refuse Disposal (March 1939); Special Committee on Hydraulic Research (February 1939).

Reports of a more technical nature were submitted by the Committee on Water Supply Engineering (Sanitary Engineering Division); and the Committee on Wind Bracing in Steel Buildings. The former was published in the March issue of PROCEEDINGS and the latter is being prepared for similar presentation in the near future.

ENGINEERS' NOTEBOOK

This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems. Reprints of the complete department, 8½ by 11 in., suitable for binding in loose-leaf style, are available each month at 15 cents a copy.

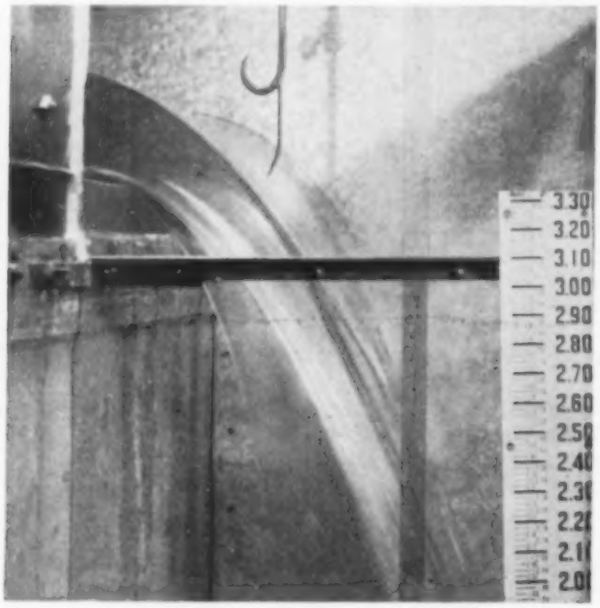
Tests of Circular Weirs

By CECIL S. CAMP, ASSOC. M. AM. SOC. C.E.
and J. W. HOWE, ASSOC. M. AM. SOC. C.E.
RESPECTIVELY ASSISTANT PROFESSOR OF CIVIL ENGINEERING, SYRACUSE UNIVERSITY; AND ASSOCIATE PROFESSOR OF MECHANICS AND HYDRAULICS, STATE UNIVERSITY OF IOWA

THE frequent use of drop inlet, or "morning glory" spillways has called attention to the need for information regarding the proper shape of the inlet below the crest. Data useful in this connection have been obtained in the laboratory of the Iowa Institute of Hydraulic Research by tests to determine the location of the upper and lower profiles of the nappe of a vertical sharp-crested weir, circular in plan. An empirical discharge formula for a circular weir has also been determined.

The tests were performed on weirs made of 10-gage steel plate having a top width of 1/32 in. and a bevel on

the downstream side at 60 deg with the horizontal. Each weir was shaped to form a circular arc having a chord length of approximately 18 in., and each had a height of about 3.5 ft (Fig. 1). Weirs having radii of 1, 2, and 3 ft were used and hence subtended central



DISCHARGE OVER CIRCULAR WEIR OF 3-FT RADIUS

angles of approximately 97, 44, and 29 deg, respectively. Radial side walls extended upstream from the weir a distance of three to four times the maximum head used and continued downstream to the point of convergence. A pyralin side wall was used downstream from the weir to permit observation of the nappe from the side.

Nappe profiles were measured by a combination hook and point gage mounted upon a carriage which was arranged to slide along a rigid horizontal beam. The beam was mounted above the weir so as to allow the gage to move in a vertical plane bisecting the arc of the weir crest.

Water was fed to the weir tank from a large constant-level tank which insured steady flow after stabilization at a particular head, and discharge measurements were made by weighing. At least two measurements of discharge and head were made on each run to check the constancy of flow. The under side of the nappe was aerated at all times. On the top side of the nappe, a roller built up at high heads causing a tailwater elevation greater than that of the crest. This roller formed when the head to diameter ratio exceeded 0.20 and caused a reduction in discharge.

The horizontal and vertical coordinates of the nappe, referred to the crest as the origin, were expressed in terms

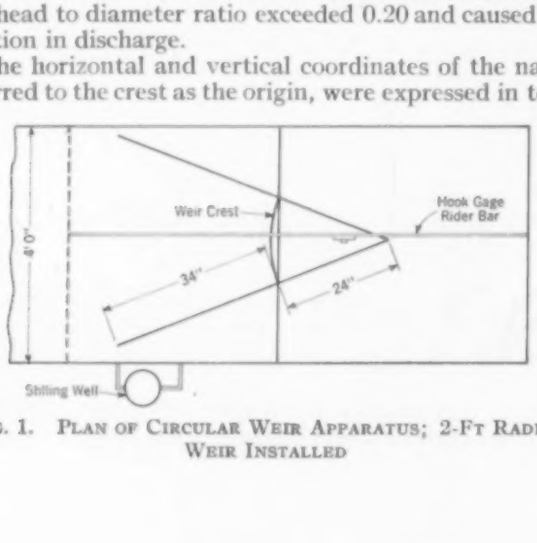


FIG. 1. PLAN OF CIRCULAR WEIR APPARATUS; 2-FT RADIUS WEIR INSTALLED

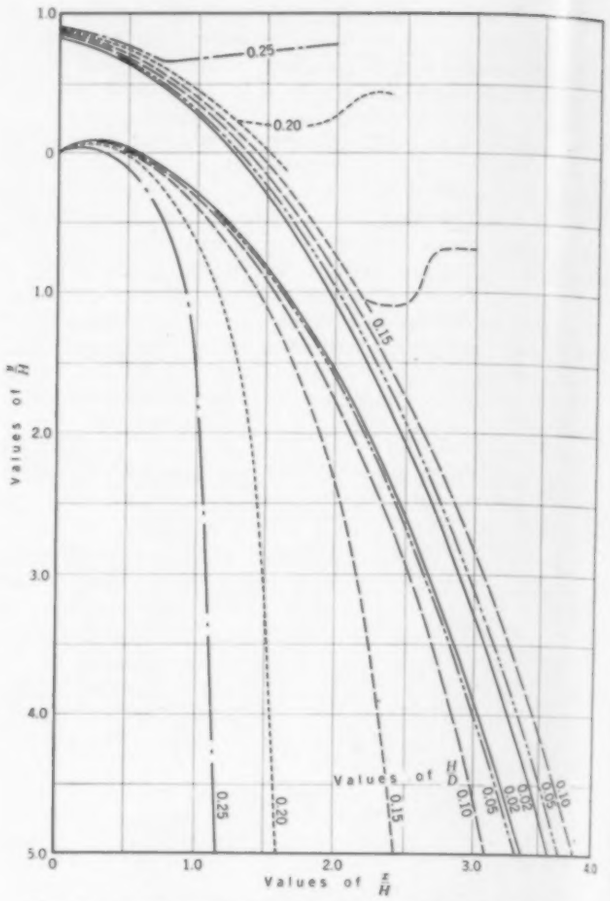


FIG. 2. SHAPE OF NAPPE FOR VARIOUS VALUES OF H/D
Origin of Coordinates Is the Weir Crest

of the head on the weir. Nappe profiles plotted in terms of these dimensionless coordinates proved to be practically identical for runs having the same ratio of head to diameter of weir arc, H/D, except in those runs in which the head was so low that the nappe adhered to the crest. Figure 2 shows upper and lower nappe profiles in terms of x/H and y/H for various values of H/D in the range covered by the experiments.

The coordinates of the high point of the lower nappe were found to be:

$$x/H = 0.26 - 0.40\ H/D \quad \ldots\ldots [1]$$

$$y/H = 0.11 - 0.20\ H/D \quad \ldots\ldots [2]$$

A logarithmic plot of discharge against head showed that nearly all the discharge measurements on the weirs could be represented by the equation,

$$Q = 3.28\ LH^{3/2} \quad \ldots\ldots [3]$$

in which Q is the rate of discharge in cubic feet per second; L, the crest length in feet; and H, the head on the crest in feet. For a full circle of crest length, πD, Eq. 3 becomes,

$$Q = 10.3\ DH^{3/2} \quad \ldots\ldots [4]$$

in which D is the diameter of the circle in feet.

Equation 3 gives results which agree with the experimental values within 1 per cent or less for values of H/D between 0.08 and 0.20. Larger errors than 1 per cent were found either side of this range, these errors being positive for lesser values of H/D and negative for larger values.

Symmetric and Anti-Symmetric Loadings

By JOSEPH S. NEWELL,

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THE analysis of indeterminate structures is tedious at best. For any given problem the engineer who is familiar with several methods of analysis may choose the one that will afford a complete and accurate solution with a minimum of computation, but if he must make an independent check by another procedure he normally finds it to be less expeditious, and it frequently happens that checking one or two values requires as much time as making the original analysis. For structures that are symmetrical, a very useful procedure, the essence of which lies in the substitution of symmetric and anti-symmetric loadings for any given system, was developed in Germany about twenty years ago (W. L. Andrée, *Das B = U Verfahren*, R. Oldenbourg, München and Berlin, 1919). It has been extended and is used by aeronautical engineers there and in this country, and is presented in brief here to call attention to its merits in the analysis or checking of symmetrical structures.

For a structure having loads symmetrically disposed about a plane of structural symmetry, it may be shown that on that plane:

1. The force components parallel to the plane—those producing shear on a section taken through the plane of symmetry—are zero.

2. The slope of the tangent to the elastic curve at the plane of symmetry is independent of the magnitudes of the applied loads.

3. The component of the deflection perpendicular to the plane of symmetry is zero.

Furthermore, the reactions on such a structure must comply with the following conditions:

4. Components parallel with the plane of symmetry must be equal in magnitude and act in the same direction.

5. Components normal to the plane of symmetry must be equal in magnitude, but act in opposite directions.

6. Moments serving to fix the slope of the structure at the supports must be equal in magnitude but of the opposite hand.

In the case of symmetrical structures having loads that are anti-symmetrically disposed, the forces having components acting toward the plane of symmetry on one side have counterparts which act away from that plane on the other; those having upward acting components on one side have downward acting counterparts on the other, and so on. Anti-symmetrical moments rotate in the same manner on each side of the plane of symmetry so that one tending to produce compression on the top fiber of a section on one side of that plane will have its counterpart producing tension on the top fiber of the corresponding section to the other side of the plane. For brevity, the plane of structural symmetry under loadings of this sort will be designated as the plane of "anti-symmetry." It may be shown that the following conditions exist on that plane:

7. The components of forces acting perpendicular to a section through the plane of anti-symmetry are zero. (This is the only condition compatible with the existence of compression on one side of the plane and tension on the other.)

8. The magnitude of the bending moment acting on the anti-symmetrical plane is zero.

9. The component of the deflection, measured parallel to the plane of anti-symmetry from a line joining the ends of the structural element through which that plane passes, is zero.

Reactions on a structure under an anti-symmetrical loading must comply with the following conditions:

10. Components parallel to the plane of anti-symmetry must be equal in magnitude, but act in opposite directions.

11. Components perpendicular to the plane of anti-symmetry must be of equal magnitude and act in the same direction.

12. Moments tending to fix the slope of the structure at points of support must be equal in magnitude and act in the same direction, viz., both clockwise or both counter-clockwise.

With the aid of these 12 conditions, most of which are self-evident, the equations of statics and the moment-area theorems, Castigliano's theorem, or similar standard methods, it is possible to analyze many structures with a minimum of numerical labor. For example, the simple bent shown in Fig. 1 (*a*) may be considered replaced by the symmetrically loaded frame of Fig. 1 (*b*), and the anti-symmetrically loaded bent of Fig. 1 (*c*). Assuming the loads of Fig. 1 (*b*) to act along the axis of the girder *bd*, and neglecting such bending as may be developed in the columns *ab* and *de* by the axial shortening of the girder, it is obvious that none of the members of this bent carry bending moments under the symmetrical load condition. Dividing the structure along the plane of symmetry and representing the forces on each half, as in Fig. 2 (*a*), M_c is zero because the loads produce no bending, V_c is zero by the first of the conditions listed above, and the other quantities follow from the equations of statics.

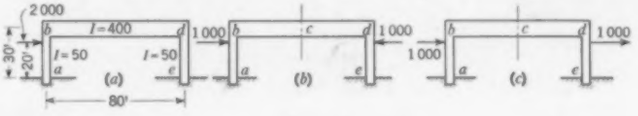


FIG. 1

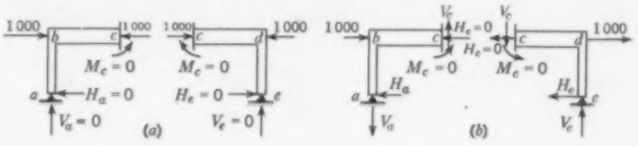


FIG. 2

Dividing the structure along the plane of anti-symmetry, and indicating the forces acting upon each half, as in Fig. 2 (*b*), M_c and H_c are zero by Conditions 7 and 8, H_a and H_e are each equal to 1,000 if $\Sigma H = 0$ on each part, and the values of V_a, V_c, and V_e are obtainable from the equations of statics. All components of the reactions necessary to the solution of this simple bent are thus determined without recourse to any of the methods normally employed in the solution of indeterminate structures, and with a minimum of arithmetic.

Had the load been applied so that bending was produced in the members, and had the columns been "fixed" at the supports, as in the case of the bent shown in Fig. 3 (*a*), the solution would not have been so short. Figures 3 (*b*) and 3 (*c*) indicate the symmetric and anti-symmetric load systems which, when superposed, would

cause the same stresses in the members as the original system under the same conditions. To determine the moments and supporting forces on this bent we may proceed as follows:

Isolating the part of the structure to the left of the plane of symmetry in Fig. 3 (*b*), and indicating the forces

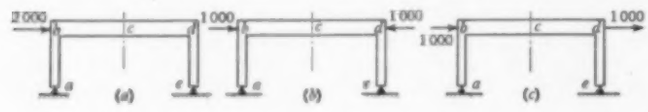


FIG. 3

acting on it, we obtain Fig. 4 (*a*). Each of these forces produces bending in one or more of the members and the resulting M/I curves are indicated in Fig. 4 (*b*), with a positive sign if the moment is such as to cause point *c* to deflect upward. $V_c = 0$ by Condition 1, and V_a must be zero if $\Sigma V = 0$ on the isolated part of

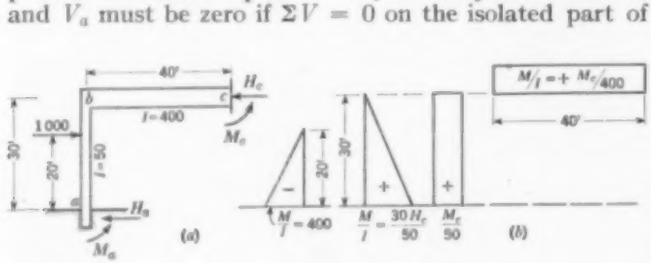


FIG. 4

the bent. By Condition 2, there is no change in slope at *c* due to the application of the load, and there is none at *a* because the support is built in. Since the change in slope between the tangents at *a* and *c* is zero, the sum of the areas under the M/I curves between *a* and *c* must, by the moment-area theorems, be zero. Then

$$30\left(\frac{30\,H_c}{50\times 2}+\frac{M_c}{50}\right)+\frac{40\,M_c}{400}-\frac{20\times 400}{2}=0 \qquad [1]$$

By Condition 3, the horizontal component of the deflection of point *c*, from the tangent to the elastic curve at *a*, is zero, so,

$$\left(\frac{30\times 30\,H_c}{50\times 2}\right)\left(\frac{2\times 30}{3}\right)+\left(\frac{30\,M_c}{50}\right)\left(\frac{30}{2}\right)-\left(\frac{20\times 400}{2}\right)\left(10+\frac{2\times 20}{3}\right)=0 \qquad [2]$$

From Eqs. 1 and 2, $M_c = -2{,}667$ and $H_c = 650$.

By isolating the left half of the bent carrying the anti-symmetric load, Fig. 3 (*c*), and indicating the forces and moments acting on it, Fig. 5 (*a*) is obtained. M_c and H_c are zero by Conditions 7 and 8, and the vertical

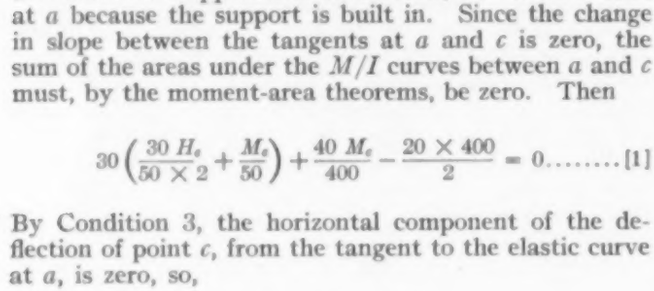


FIG. 5

deflection of point *c* from a line through *b* and *d* is zero by Condition 9. The latter relation suffices for the determination of V_c since the slope at *b*, assuming angle *abc* remains a right angle, is

$$E\theta_b=\frac{-400\times 20}{2}+\frac{30\times 40\,V_c}{50}$$

Were there no bending in *bd*, point *c* would deflect $40E\theta_b$ below the line *bd*. For the deflection of point *c* to be zero, the deflection of *c* from the tangent to the elastic curve at *b* must equal $-40E\theta_b$, so

$$-\left(-\frac{400\times 20}{2}+\frac{30\times 40\,V_c}{50}\right)40=\left(\frac{40\,V_c}{400}\times\frac{40}{2}\times\frac{2\times 40}{3}\right) \qquad [3]$$

V_c, from Eq. 3, is 158, and by the equations of statics, $H_a = 1{,}000$, $V_a = 158$, and $M_a = 13{,}680$ for the anti-symmetric load. For the original structure, $V_a = 158$, $H_a = 1{,}350$, and $M_a = 16{,}850$. With these known, the right reactions are determinable by simple statics.

For the third example consider the two-story bent of Fig. 6 (*a*). A solution of this structure, made by the slope-deflection method, is presented in Article 35 of Fife and Wilbur's *Theory of Statically Indeterminate Structures*. The solution, with relatively few explanatory remarks, covers some $5\frac{1}{2}$ pages of that text, gives the moments adjacent to the panel points but does not include the computations involved in obtaining the axial loads and shear forces on each member. To check Fife and Wilbur's results we separate the given loads into a symmetrical system, Fig. 6 (*b*), and an anti-symmetric system, Fig. 6 (*c*).

Since the loads are applied to produce no bending in the members of the symmetric system, $H_g = H_{g'} = 50$, $H_h = H_{h'} = 12.5$, and M_g, M_h, H_a, H_f, V_a, and V_f are zero by the equations of statics or by the fact that the members are not subjected to bending. The loads acting in each member of the structure of Fig. 6 (*b*) are

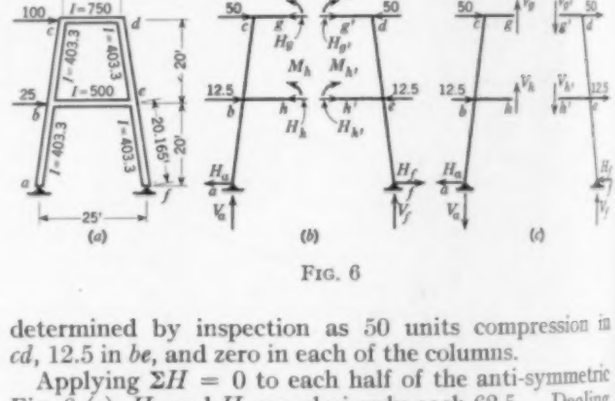


FIG. 6

determined by inspection as 50 units compression in *cd*, 12.5 in *be*, and zero in each of the columns.

Applying $\Sigma H = 0$ to each half of the anti-symmetric Fig. 6 (*c*), H_a and H_f are obviously each 62.5. Dealing with the structure as a whole, not cut along the plane of anti-symmetry, and taking moments about *a*, $100\times 40+25\times 20-25\,V_f=0$, whence $V_f = 180$. Then $V_a = -180$, and on the part of the structure to the left of the plane of anti-symmetry, $V_g + V_h - 180 = 0$, so we are faced with one equation and two unknowns, with a structure which is indeterminate to the first degree. Although there is no point at which the slope of any member is known or readily determined, it is to be observed that for small deflections, point *c* moves downward a certain amount, and point *d* upward by the same amount, the difference due to the change in length of *cd* being neglected. Then point *g* which, by Condition 9, lies on a straight line connecting *c* and *d*, does

not deflect vertically. By the same reasoning, point k in member *be* suffers no vertical deflection. Since we already established a relation between V_g and V_h, we may use Castigliano's theorem to obtain one or the other and complete the solution of the problem. The modulus of elasticity of the material in all members being the same, E times the work due to bending in the part of the structure to the left of the plane of antisymmetry is

$$EW = \int_0^{7.5} \frac{(-V_g x)^2 dx}{2 \times 750} + \int_{7.5}^{20.165} \frac{\left[\left(-7.5 - \frac{2.5\,x}{20.165}\right) V_g + 50x\right]^2 dx}{2 \times 403.3} + \int_0^{10} \frac{(-V_h x)^2 dx}{2 \times 500}$$

(The bending in column *ab* is omitted because it may be written independently of V_g or V_h.)

Substituting $180 - V_g$ for V_h in the preceding expression, differentiating with respect to V_g, setting the derivative equal to the deflection at the point where the force V_g is applied—zero since point g does not deflect parallel to that force—and solving for V_g, establishes the magnitude of V_g as 74.2. Then $V_h = 105.8$ and the shears, axial loads, and bending moments in the various members may be determined by the equations of statics. It will be found that they agree with the values shown in Fig. 76 of Fife and Wilbur's book, and it may be demonstrated that the determination of V_g and the evaluation of the various shears and moments requires only about one page of computation, so that a complete check of what appears to be a complicated problem may be had, in this case, with a relatively small expenditure of time.

It is admitted that the examples used here have been chosen because of their simplicity and their value in demonstrating the steps to be followed in solving indeterminate structures by the method under discussion. Not all structures can be analyzed so readily, but the engineer who experiments with, and masters, the method will have one more tool to assist him in analyzing or checking symmetrical structures.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Economic Factors of Hydro Plant Design

TO THE EDITOR: Mr. Gerdes' paper particularly interested the writer, who in the past has gathered and attempted to analyze hydro plant cost data. Also some years ago the National Electric Light Association gathered and analyzed much similar data, but its committee was unable to determine a mathematical expression for plant cost at given head. Only very general conclusions on cost range could be reached. Incidentally, a few very low head plants showed among the lowest unit costs—a fact exactly contrary to Mr. Gerdes' trend curve and formulas.

I have been intrigued by the mathematical expressions for hydro plant cost and have studied their possible useful application. As a result I am firmly convinced that any attempt to utilize such expressions or curves for estimating purposes or as measures of reasonable cost of existing hydro plants is both dangerous and misleading. This opinion does not apply to equipment cost curves which, with allowance for market conditions, may be quite useful in making rough reconnaissance estimates.

Hydroelectric plants are custom made. Each is designed and constructed to suit a particular site with varying flow and load conditions, topography, and geology. Even with identical installed capacities at two given sites these different conditions mentioned would require materially different designs and construction methods. Also costs of labor, material, and transportation vary with location and time of building. Plant capacity will affect unit kilowatt cost. In general large plants with a few large units will have lower unit cost than small plants with a number of small units. All these factors have such great and varying importance that any attempt to derive mathematical formulas for hydro plant cost must prove abortive. Although these numerous variables necessarily affect the cost, Mr. Gerdes in his studies recognizes only one—the head.

He states that "For hydroelectric power plants the appropriate unit by which to measure both design and construction efficiency in terms of cost appears to be the installed capacity in kilowatts, and accordingly this unit has been used for the general comparisons of this study." In other words, the "unit kilowatt cost."

If this were true, any plant of low unit cost would be considered as either efficiently designed, or executed, or both. How could one tell which by this simple rule? Conceivably, a low construction cost (not necessarily efficient) might obscure a very wasteful design. Low unit cost can never be a measure of efficiency of design. Sometimes a costly design is required and sometimes a cheap one. The owner's only assurance of efficient design is to engage engineers with a record of proved ability and successful achievement.

Likewise in investigating efficiency in design of existing plants, a practicable method would be to employ a competent board of engineers who would have practically to duplicate the work of the original designers, as of the date constructed.

Low unit kilowatt cost is, moreover, not an index of efficient construction as more than a score of inherent variables, which space does not allow enumerating here, enter into construction costs. Here also the owner's best assurance is to engage a construction organization of successful specialization in power plants. With all these variables, simple formulas such as $227/\sqrt[4]{H}$ or $184/\sqrt[4]{H}$ provide no short cut in determination of efficiency of design or construction.

The plants studied are widely scattered throughout the country with differing cost conditions. They were built from 1918 to 1938, during which period the *Engineering News-Record* cost index varied by 60 per cent.

For future units Mr. Gerdes allocated out a part of reported costs. To estimate with any degree of accuracy the ultimate unit cost, one must estimate the cost of future units at the time of construction, add this result to the licensee's reported figure, and divide by the ultimate capacity. The work involved in properly making such an estimate on the plants studied would be tremendous. However, without doing it his estimated unit costs mean nothing.

JOEL D. JUSTIN, M. Am. Soc. C.E.
Consulting Engineer
Philadelphia, Pa.

TO THE EDITOR: I read Mr. Gerdes' paper with considerable interest, especially since I have been connected with the design and construction of a number of the stations he includes in his analysis. Mr. Gerdes' comparisons have been limited to the power plant station section only, and such a limited study omits many of the controlling elements of true economy of design and construction. The most economical complete development of water power sites should be basic with all hydraulic engineers and constructors. However, they must consider not only the construction cost of the total de-

velopment, but also the annual operating cost per unit of useful output of capacity and energy, giving proper weight to each. A consideration of only the power station section is bound to give a distorted picture, as it is impossible to properly weight the costs and quantities in such a limited portion of the total development.

In the comparison of quantity of concrete per kilowatt, I would particularly call attention to the effect of the site on two of the plants, namely Bagnell and Conowingo. Mr. Gerdes compares these without any adjustment for variations in site; whereas at Bagnell the natural rock-foundation level was approximately at the level of the bottom of the draft tubes, and at Conowingo the bottom of the draft tubes was about 30 ft below the natural rock-foundation level. At Bagnell, the mass concrete under the intake section extends down approximately to the bottom of the draft tubes, whereas at Conowingo the bottom of the intake-section concrete is about 20 ft above the bottom of the draft tubes. Under such conditions, a comparison of the quantity of concrete in these two plants without adjusting for the site differences would obviously be worthless as tending to show a trend in quantity per kilowatt. Undoubtedly a complete study of other plants included in the analysis would show that the site has more influence on the quantity of concrete required than the features within the control of the designer.

Mr. Gerdes' comparison of the unit cost of stations per cubic foot of superstructure has been made without adjusting the costs for major differences in design and site conditions which are controlling elements in the economics of the various sites. For instance, at the Rock Island development on the Columbia River, tailwater level resulting from a major flood is 30 ft above the generator-room floor, and the walls of the power station must be designed to withstand the resultant pressure. At many other stations the maximum tailwater level is below the level of the generator-room floor, and the station walls required only the normal light type of construction. Also, the Conowingo Station superstructure is designed to support the high tension switching station and the transmission get-away structure on the roof, whereas at Safe Harbor and many of the other plants the substation is on the bank adjacent to the power station. It should be evident that a comparison of these superstructure costs that does not make adjustment for such differences would be worthless for purposes of a study of design efficiency.

In hydroelectric as in other types of engineering, comparisons of parts or of individual items without proper consideration of all the elements of control will appear to indicate errors of judgment and economy, whereas full comparisons with all the controlling elements properly considered may show the designs to be logical and efficient. I am of the opinion that partial comparisons of hydroelectric projects such as those made by Mr. Gerdes are difficult to properly weight for all the varying conditions at various sites and are generally very misleading.

G. R. STRANDBERG, M. Am. Soc. C.E.

Boston, Mass.

TO THE EDITOR: The paper, "Hydro Power Plant Space and Cost Trends," by H. G. Gerdes, in the January issue of CIVIL ENGINEERING, is an interesting attempt to make cost comparisons between various structures without being in possession of the necessary detailed information on which such comparisons must be based to be of any value. Mr. Gerdes states in his opening paragraph that his study was made to obtain more accurate cost data for "estimating" and later from a "feeling" that the more fundamental factors governing the economics of power plant design are too little considered.

It is difficult to see how the data he has submitted would help anyone in the preparation of an estimate, unless he wishes to leave the impression that it would be safe to use the formulas given in Figs. 1 and 4 of his paper. These formulas are certainly not based on any very definite trend lines. The trend of these lines is anything but definite. Any engineer experienced in hydroelectric plant design knows how dangerous it is to make casual comparisons where conditions are never twice alike. It might be thought that such apparently standardized equipment as water-wheel-type vertical generators should follow a definite trend line, but Fig. 3 (*b*) shows that this is not the case. Anyone experienced in such matters realizes the tremendous difference in cost of generators such matters as voltage, fly-wheel effect, direct connected or separately driven exciters, etc., make. Since generators are the most nearly comparable feature of a hydro plant and yet cannot be properly compared without a full knowledge of all the data regarding them, it must be evident that other features of hydro plants, the details of which are largely controlled by natural conditions that vary greatly, cannot be properly compared. Space does not permit a recitation of the reasons why a simple comparison cannot be made.

One should have more than a "feeling" that work carried out by others neglected the fundamental factors of economic design. If there has been such neglect, an experienced designer should have little difficulty in pointing out specific instances. It, furthermore, seems improper to make cost comparisons without bringing all costs to the same index. Costs of construction and equipment have varied tremendously during the past twenty-five years and sometimes during a single year of this period. The cost of building materials and labor is also known to have been variable in different parts of the country. The paper seems critical of the great variation in cost of hydro plants but offers nothing constructive to show how this could be otherwise.

W. F. UHL, M. Am. Soc. C.E.

Boston, Mass.

Closure of Discussion on Retaining Wall Footings

TO THE EDITOR: The February 1939 issue of CIVIL ENGINEERING contains a discussion by Prof. Roe L. Stevens on the design of retaining wall footings, in comment on my article in the November 1938 number, which pointed out the danger of the excessive bond stresses that may exist under a wall shaft.

The vital assumption in Professor Stevens' discussion is that tension exists in reinforcement embedded in the concrete which is in compression, and at the plane of contraflexure under the wall shaft. But this is a pure assumption, and is proved here to be a fallacy. He bases his discussion on the surprising statement that compression exists around the tensile reinforcement at the plane of contraflexure, but he gives no hint of what force can cause this compression. No explanation is made of how large compressive stress can exist around the tension reinforcement at, and immediately adjacent to, the plane of contraflexure, and not also extend some distance on the tension side.

Such conditions would mean tensile and compressive stresses existing together along both the top and bottom of the footing simultaneously, since the conditions are the same there on alternate sides of the plane of contraflexure. If tension in the reinforcement can pass the plane of contraflexure at the bottom of the footing, it must logically be assumed to do so simultaneously at the top in a like amount. But this would eliminate the effectiveness of the short cantilevers under the shaft, which balance the heel and toe moments. The discussion is based on the assumption that the total tension in the reinforcement at the plane of contraflexure is numerically equal to the total compression there in the concrete around the reinforcement. All this leads to a jumble of opposing stresses, and no explanation of how they could come into existence is suggested.

No compression exists in the concrete except that resulting from moment. Adjacent to the plane of contraflexure the compression is small and equal to the tension in the reinforcement on the opposite side of the beam. Yet tension in the reinforcement on the compression side is assumed to be relatively large. How, then, can tension exist in the reinforcement on the compression side when there is no other force to balance it or to cause excess compression around the reinforcement, as assumed? If compression were assumed to exist on the opposite side of the beam to balance this tension, it would be equivalent to assuming a resisting couple acting in the opposite direction to the regular resisting moment, and therefore neutralizing it.

Professor Stevens inaptly uses the familiar test for bond to illustrate the conditions at a plane of contraflexure. In a bond test the compression and shear around the bar embedded in the concrete block are induced by an external force acting in the opposite direction to the tension in the bar. No such opposing force acts on a footing to cause compression at the plane of contraflexure, or at any other transverse plane. The external forces acting on the footing are at right angles to the reinforcement, except the earth pressure at the rear, which is transmitted by shear in the footing

to the soil under it. Also, the toe and heel segments of the footing outside the shaft rotate about the centers of moment in the same direction as the stresses in the reinforcement. This leaves no possible force to act against tension in the reinforcement on the compression side or to produce around it compression in excess of that due to moment. This nullifies the vital assumption of Professor Stevens' discussion.

HARRY E. ECKLES, M. Am. Soc. C.E.
Assistant Highway Engineer,
State Division of Highways

Springfield, Ill.

Recent Salary Data

TO THE EDITOR: In connection with the report of the Committee on Salaries, on page 111 of the February issue of CIVIL ENGINEERING, the following facts and figures may be of interest to our members.

An analysis of authentic information recently secured has just been completed as to the actual salaries paid during the year 1938 to 23,741 engineers distributed through practically every state in the Union, and doing fairly comparable work in all grades from subprofessional classes to positions with the title of chief engineer. In only one group, aggregating only slightly over 400 men (including those from the subprofessional classes to the chief), were salaries consistently higher than the ones suggested in the report. Among the 24,000, the total number of men who had received more than $3,840, and who by any stretch of the imagination might be considered by budget officials as having been overpaid (looking only at the rates printed but ignoring the explanatory notes in the report), was less than 2.7 per cent. On the other hand, over 15,000 men, or practically 65 per cent, were definitely underpaid on the basis of the suggested scale of compensation.

The geographical distribution of the areas in which the relatively few engineers are located who might conceivably be considered to have been overpaid, included the whole United States, with surprising uniformity from Canada to Mexico and the Gulf and from the Atlantic to the Pacific. Consequently, it would be found impossible to create geographical areas with salary differentials which would give rates more closely approaching the ideal than do those in the Committee's report.

Correlation studies between the areas in which the engineers who constitute the 2.7 per cent reside and the latest cost-of-living statistics again fail to show possibilities of improvement by use of a differential factor for that characteristic.

A third line of investigation had reference to the use of a sliding scale of compensation rates, on the basis of a ratio between the salaries of Grades I and III for example. Such a scale would obviously have to be promulgated on a more or less arbitrary basis, such as proportionality to community or sectional wealth, and the "prevailing rates of pay" therein.

The Committee is continuing these correlation studies and is also endeavoring to secure authentic salary data with reference to 25,000 additional engineers. Informed discussions or comments on the report are solicited, for transmitting direct to the Committee.

E. P. GOODRICH, M. Am. Soc. C.E.
Chairman, Committee on Salaries

New York, N.Y.

Closure of Discussion on Fixed-Point Theory

TO THE EDITOR: I have read with great interest the letter by R. W. Stewart, in the February issue, pertaining to my article on "The Fixed Point Theory for Continuous Beams with Elastic Supports," and have noted his statements that the use of drafting instruments may lead to inaccuracy, that it tires the computer, and that it is time-consuming.

It is also stated that my values were incorrect by varying amounts up to 22 per cent, and that the method presented by Mr. Stewart provides an automatic check against errors. After careful checking of my values, I am inclined to believe that the results obtained by Mr. Stewart are incorrect by varying amounts up to 22 per cent.

It is not necessary to rely on drafting instruments to obtain the moments in a frame from the use of the fixed point theory. This method can easily be used to plot the fixed points and the moments by free hand and, by using the figures obtained as a guide, for simple arithmetical computations, as has been shown here.

The left fixed point distance (Fig. 1) is determined by

$$a_1 = \frac{L_1 c_1}{3c_1 + e^a_1} \quad \ldots\ldots [1]$$

where c_1 is the deflection angle of beam (1) at support A for a moment $m = 1$, applied in support B. We know that $c_1 = \frac{L_1}{6EI} = \frac{2.5}{2EI}$, and e^a_1 is the deflection angle of support A for a moment of unity applied at this support. For this special case, where the support

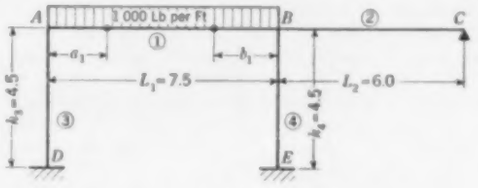


FIG. 1.

consists of only one member, it is known that $e^a_1 = t^A_3$, where t^A_3 is the deflection angle in support A for column (3) for a moment in A of $M = 1$. For this case, with full restraint at D, $t^A_3 = h_3/4EI = 4.5/4\ EI$. Therefore the left fixed point distance is computed by the use of Eq. 1 to be $a_1 = 25/13 = 1.923$ ft.

The right fixed point distance is

$$b_1 = \frac{L_1 e_1}{3c_1 + e^b_1} \quad \ldots\ldots [2]$$

where e^b_1 is the deflection angle of support B for a moment, $M = 1$, applied at this support. For this special case, where the support is composed of two members, we get $e^b_1 = t^B_{2-4}$, where t^B_{2-4} is the deflection angle in support B for members (2) and (4) for a moment, $M = 1$, applied in support B. It is known that $t^B_{2-4} = \frac{1}{1/t^B_2 + 1/t^B_4}$ with $t^B_2 = L_2/3EI = 2/EI$ and $t^B_4 = h_4/4EI = 4.5/4EI$. Hence $t^B_{2-4} = 18/25EI$. Therefore the right fixed point distance is computed by the use of Eq. 2 to be $b_1 = 625/298 = 2.097$ ft.

As soon as we know the fixed points, the moments are plotted as shown in Fig. 2. Simple calculations will give

$$y_a = \frac{wL}{4}\ a = \frac{1{,}000 \times 7.5}{4}\ \frac{25}{13} = 3{,}605.77,$$

$$y_b = \frac{wL}{4}\ b = \frac{1{,}000 \times 7.5}{4}\ \frac{625}{298} = 3{,}932.47$$

The increase in the moment from R to B will easily be found to be $326.70 \times 2.097/3.480 = 196.8$, and the decrease in the moment

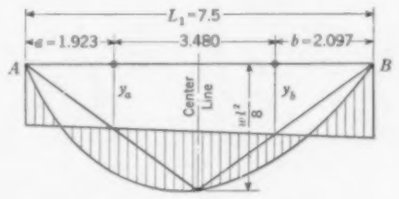


FIG. 2.

from L to A is $326.7 \times 1.923/3.480 = 180.5$. Hence, the moments become $M^A = 3{,}605.77 - 180.50 = 3{,}425.27$ and $M^B = 3{,}932.47 + 196.80 = 4{,}129.27$.

It will be noted that in this solution no approximations have been made, that the method has a general application, and that any desired degree of accuracy can be obtained.

ODD ALBERT, Assoc. M. Am. Soc. C.E.
Assistant Professor of Structural Engineering, Newark College of Engineering

Newark, N.J.

Density Currents in Reservoirs and Lakes

DEAR SIR: CIVIL ENGINEERING for January (pages 36 and 37) contains an excellent description of density currents in a reservoir, by Jack L. Hough. Mr. Hough has pointed out that the denser inflowing water did not disappear beneath the surface until it had traveled some little distance in each arm of the reservoir. While there are probably other contributing factors, the writer believes that the principal reason for this is because the inflowing water was turbulent, whereas the flow through the reservoir was normally laminar flow. Eddies thrown off from the sides and bottom of the channel would travel to the surface, creating an upward current, which would be balanced by an equal downward current of the surface water, thus providing complete mixing for such distance from the entrance of the reservoir as would be required to eliminate turbulence from the inflow. Thereafter the flow of both the turbid and reservoir water would be laminar, mixing would cease, and the denser water would settle to and remain at the bottom. The writer has once or twice observed a similar condition, and has also observed the opposite condition of warm, turbulent water flowing into still, colder water and riding for a considerable distance at, and a little above, the surface of the latter.

Some geologist with naive indefiniteness has defined a lake reach in a river as "an enlarged portion of a river channel." This suggests a definition of a lake reach in a river channel which has not, so far as the writer is aware, hitherto been given, and which provides a fairly definite basis of demarcation between lake and river reaches. A lake may be described as a body of water in which the flow is predominately laminar. This applies both to lakes in river channels and to other lakes. In river reaches, on the contrary, the flow is predominantly turbulent. This distinction in type of flow as between lake and river reaches is the basis of significant differences in both the hydraulics and hydrology of lakes and rivers. It accounts for the possibility of the existence of density currents in the former, as well as for the fact that thermal stratification commonly exists in lakes and is absent in rivers.

ROBERT E. HORTON, M. Am. Soc. C.E.
Consulting Engineer

Voorheesville, N.Y.

Data on Rainfall for the Larger Drainage Areas

DEAR SIR: Under the title, "The Maximum Probable Flood and Its Relation to Spillway Capacity," Messrs. S. M. Bailey and G. R. Schneider have presented, in the January issue, information concerning probable maximum rainfalls which, in form, is of great convenience to engineers concerned with the design of spillways. However, there may be material deviations from correct values for some localities.

Attention is directed herewith to some facts which may lead to considerable modification of the figures and location of the isohyetals of maximum probable rainfall for the larger drainage areas, as shown on maps (*c*) and (*d*) of the authors' Fig. 1. These modifications could, and probably will, result from a different method of treating the basic data as illustrated by Fig. 1 herewith. This map was prepared by dividing the eastern half of the United States into 50-mile squares and then noting in each square the number of times that the "square" had been inside of, or touched by, the 6-in. isohyetal of a great storm as defined by the engineers of the Miami Conservancy District and mapped in Part V of their Technical Reports. Lines of equal frequency were then drawn to include those squares which showed exactly, or more than, the number of occurrences represented by the line. This map includes not only all the data given in the 1936 edition of Part V, but also that for the great storms of 1936 and 1937.

There appears to be a very marked regional variation in frequency of great storms; and if the map is compared with the profile of intensities of great storms along a line midway between the Appalachians and the Atlantic Coast (see page 1297 of the PROCEEDINGS of the Society for June 1938), it also appears that the frequency may be related to the intensity, and if this is true then maps (*c*) and (*d*) by Messrs. Bailey and Schneider do not even approximate the correct picture.

The most striking fact developed by this map is the existence of an area approximately 200 miles wide along the western slopes of the Appalachians, extending northeasterly from the northern border of Alabama, in which, with the exception of a small area in West Virginia, no "great storm" has occurred since records began in 1892. The West Virginia area was covered by one storm which just reached the required dimensions for a great storm. Based on a frequency map of this type, it would require quite a stretch of the imagination to even say that a maximum rainfall of 9 in. in two days (50 per cent more than the Miami standard, which calls for 6 in. in three days) is the probable maximum for a drainage area of 50^2 or 2,500 sq miles in eastern Kentucky, whereas interpolation of Messrs. Bailey and Schneider's maps would infer figures on the order of 13 in. Attention is directed to this area because it is a region in which many flood control and power dams may be built in the future and, therefore, is of particular interest, as over-generalization may, in some cases, lead to the initiation of much needless expenditure.

Maps (*a*) and (*b*) probably are approximately correct, because there are records of several storms of the cloudburst type in the Appalachian region, which approach the values shown. It may be that the shape and spacing of isohyetals as developed for rainfalls on small areas were permitted to influence the shape and spacing for the larger areas, producing a pattern that is materially different from that of the accompanying map.

FIG. 1. RELATIVE FREQUENCY OF GREAT STORMS IN EASTERN UNITED STATES

Total Number of Great Storms Recorded Since 1892 Is Shown by Dash Lines Passing Through Areas of Equal Frequency. No Great Storms Have Occurred in Shaded Areas. (A "Great Storm" Shows a Total of 6 In. of Rainfall at Five U. S. Weather Bureau Stations.)

The entire subject of maximum rainfall is being intensively studied by the U. S. Weather Bureau (see article on "Progress in Weather Forecasting" in the October issue of *Electrical Engineering*), and it is to be hoped that their findings will ultimately be presented in a convenient form similar to that used by Messrs. Bailey and Schneider, also that data giving actual figures for total flood runoff from maximum storms on smaller drainage areas will be included.

ROBERT F. EWALD, M. Am. Soc. C.E.
Hydraulic Engineer, Aluminum Company of America

Pittsburgh, Pa.

Spring Meeting in Chattanooga, Tenn.

Hotel Patten to Be Headquarters, April 19–22, 1939
Program of Meetings, Entertainment, and Trips

Opening Session and General Meeting

WEDNESDAY—April 19, 1939—Morning

9:00 **Registration**

9:45 **Spring Meeting called to order by**

LEE G. WARREN, *M. Am. Soc. C.E., President, Tennessee Valley Section, Am. Soc. C.E.; Project Engineer, Chickamauga Dam, TVA*, Chattanooga, Tenn.

Invocation

REV. THORNE SPARKMAN, *Rector of St. Paul's Church*, Chattanooga, Tenn.

9:50 **Addresses of Welcome**

HIS EXCELLENCY PRENTICE COOPER, *Governor of the State of Tennessee*, Nashville, Tenn.

HIS HONOR E. D. BASS, *Mayor of Chattanooga*

10:05 **Response**

D. H. SAWYER, *President, American Society of Civil Engineers*, Washington, D.C.

10:10 **The Construction Program and Activities of the Tennessee Valley Authority**

THEODORE B. PARKER, *M. Am. Soc. C.E., Chief Engineer, Tennessee Valley Authority*, Knoxville, Tenn.

11:10 **Discussion opened by**

A. C. POLK, *M. Am. Soc. C.E., Consulting Engineer*, Birmingham, Ala.

J. P. GROWDON, *M. Am. Soc. C.E., Chief Hydraulic Engineer, Aluminum Company of America*, Pittsburgh, Pa.

12:00 **Announcements**

12:05 **Luncheon Recess**

WEDNESDAY—April 19, 1939—Afternoon

1:40 **Flood Control of Mississippi River**

BRIG. GEN. HARLEY B. FERGUSON, *M. Am. Soc. C.E., President, Mississippi River Commission, and Division Engineer, Lower Mississippi River Valley Division*, Vicksburg, Miss.

2:30 **Discussion opened by**

W. E. ELAM, *M. Am. Soc. C.E., Assistant Engineer, Mississippi Levee Board*, Greenville, Miss.

GERARD H. MATTHES, *M. Am. Soc. C.E., Principal Engineer, Office of President, Mississippi River Commission*, Vicksburg, Miss.

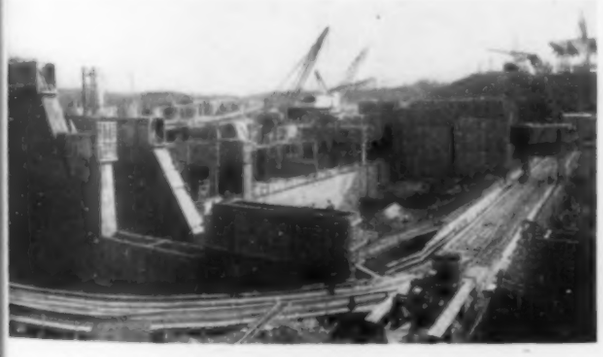
3:00 **Aluminum Structural Shapes and Their Application to Engineering Structures**

D. J. BLEIFUSS, *Assoc. M. Am. Soc. C.E., Assistant Hydraulic Engineer, Aluminum Company of America*, Pittsburgh, Pa., and B. J. FLETCHER, *Assoc. M. Am. Soc. C.E., Civil Engineer, Aluminum Company of America*, New Kensington, Pa.

3:45 **Discussion opened by**

ROSS M. RIEGEL, *M. Am. Soc. C.E., Head Civil Engineer, Design Department, Tennessee Valley Authority*, Knoxville, Tenn.

At the close of the discussion, a film on "Aluminum Production and Manufacture" will be shown.



CONSTRUCTION OPERATIONS, CHICKAMAUGA DAM

CONSTRUCTION VIEW, CHICKAMAUGA DAM

WEDNESDAY—April 19, 1939—Evening

7:00 Dinner and Entertainment at Hotel Patten for Members, Ladies, and Guests.

Presiding: LEE G. WARREN, *M. Am. Soc. C.E., President, Tennessee Valley Section, Am. Soc. C.E.,; Project Engineer, Chickamauga Dam, TVA*, Chattanooga, Tenn.

Speaker: EDMUND F. PREECE, *M. Am. Soc. C.E., Senior Engineer, National Park Service*, Washington, D.C., on "National Parks of the United States" (illustrated in colors).

Tickets for the dinner and evening's entertainment are $1.50 each. Tickets to students are 75 cents each.

Sessions of Technical Divisions

THURSDAY—April 20, 1939

SOIL MECHANICS AND FOUNDATIONS DIVISION

Morning and Afternoon

CARLTON S. PROCTOR, *Chairman, Executive Committee, Presiding*

9:30 Opening by

CARLTON S. PROCTOR, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

9:35 Foundation Exploration and Geologic Studies, Chickamauga Dam

PORTLAND P. FOX, *Associate Geologist, Tennessee Valley Authority*, Chattanooga, Tenn.

10:20 Discussion opened by

O. N. FLOYD, *M. Am. Soc. C.E., Consulting Engineer*, Dallas, Tex.

BERLEN C. MONEYMAKER, *Geologist, Tennessee Valley Authority*, Knoxville, Tenn.

10:40 Foundation Treatment, Chickamauga Dam

JAMES B. HAYS, *M. Am. Soc. C.E., Construction Engineer, Chickamauga Dam, TVA*, Chattanooga, Tenn.

11:25 Discussion opened by

C. E. BLER, *M. Am. Soc. C.E., Project Engineer, Tennessee Valley Authority*, Hiwassee Dam, N. C.

12:00 Luncheon Recess

2:00 Report of Committee on Soil Sampling and Testing

DR. MIKAEL J. HVORSLEV, *Assoc. M. Am. Soc. C.E., Research Engineer, Graduate School of Engineering, Harvard University*, Cambridge, Mass.

2:45 Discussion

3:00 Foundation Exploration and Geologic Studies, Guntersville Dam

ROBERT M. ROSS, JR., *Geologist, Tennessee Valley Authority, Guntersville Dam*, Ala.

3:15 Discussion opened by

DR. L. C. GLENN, *Professor, Department of Geology, Vanderbilt University*, Nashville, Tenn.

3:35 Foundation Treatment, Guntersville Dam

VERNE GONGWER, *M. Am. Soc. C.E., Project Engineer, Guntersville Dam, TVA*, Guntersville Dam, Ala.

4:00 Discussion opened by

GEORGE K. LEONARD, *M. Am. Soc. C.E., Construction Engineer, TVA, Guntersville Dam*, Ala.

SURVEYING AND MAPPING DIVISION

Morning and Afternoon

WILLIAM BOWIE, *Chairman, Executive Committee, Presiding*

9:30 Trends in Boundary Surveying

A. H. HOLT, *M. Am. Soc. C.E., Head, Department of Civil Engineering, Worcester Polytechnic Institute*, Worcester, Mass.

10:10 Discussion

10:40 Recess

10:45 The Need for Topographic Maps in Regional and Local Planning

R. H. RANDALL, *M. Am. Soc. C.E., Consulting Engineer*, Washington, D.C.

11:30 Discussion

12:00 Luncheon Recess

2:00 Atlanta City Survey

R. W. TORRAS, *Assoc. M. Am. Soc. C.E., Engineer and Secretary, City Planning Commission*, Atlanta, Ga.

2:40 Organization of TVA Surveying and Mapping Activities

NED H. SAYFORD, *M. Am. Soc. C.E., Head Engineer, Maps and Surveys Division, Tennessee Valley Authority*, Chattanooga, Tenn.

3:20 Stereoscopic Plotting Instruments in Topographic Mapping

T. P. PENDLETON, *M. Am. Soc. C.E., Assistant Section Chief, U. S. Geological Survey*, Chattanooga, Tenn.

4:00 Discussion

In addition to the above papers and discussions, it is planned to present an exhibit of some of the high-powered instruments in use, photographs of a tape-calibrating station, exhibits to illustrate land acquisition maps from aerial photographs, and exhibit to illustrate multiplex mapping, stereoplanigraph mapping, and miscellaneous photographs illustrating unusual surveying practices.

Student Luncheon and Conference

THURSDAY—APRIL 20, 1939

12:30 Luncheon

1:15 Speakers

D. H. SAWYER, *President Am. Soc. C.E.*; T. KEITH LEGARÉ, *and* T. R. AGG, *Members, Board of Direction, Am. Soc. C.E.*

2:15 Student Papers

3:30 Discussion of Student Chapter Activities

4:30 Award of Prizes

Sessions of Technical Divisions

THURSDAY—APRIL 20, 1939

HYDRAULICS DIVISION

Morning and Afternoon

FRED C. SCOBEY, *Chairman, Executive Committee, Presiding*

9:30 **Interesting Hydraulic Phenomena, Based on the Hydraulic Jump** (Illustrated by Lantern Slides)

FRED C. SCOBEY, *M. Am. Soc. C.E., Senior Irrigation Engineer, U. S. Department of Agriculture,* Berkeley, Calif.

10:10 **Determination of Discharge at Gaging Stations on Streams Effected by Variable Slope**

M. C. BOYER, *Jun. Am. Soc. C.E., Assistant Engineer, U. S. Geological Survey,* Silver Spring, Md.

10:35 **Discussion opened by**

C. H. PIERCE, *M. Am. Soc. C.E., Senior Hydraulic Engineer, Water Resources Branch, U. S. Geological Survey,* Washington, D.C.

F. C. AMES, *Assistant Hydraulic Engineer, U. S. Geological Survey,* Chattanooga, Tenn.

D. E. DONLEY, *Assoc. M. Am. Soc. C.E., Hydraulic Engineer, Tennessee Valley Authority,* Knoxville, Tenn.

11:00 **The Hydraulic Laboratory in the TVA Program** (Illustrated with Moving Pictures)

G. H. HICKOX, *Assoc. M. Am. Soc. C.E., Senior Hydraulic Engineer, Tennessee Valley Authority,* Norris, Tenn.

11:30 **Discussion opened by**

PAUL W. THOMPSON, *Jun. Am. Soc. C.E., Lieutenant, Corps of Engineers, U.S.A., Director, U. S. Waterways Experiment Station,* Vicksburg, Miss.

12:00 **Luncheon Recess**

2:00 **Vicissitudes of an Engineering Formula**

S. M. WOODWARD, *M. Am. Soc. C.E., Chief Water Control Planning Engineer, Tennessee Valley Authority,* Knoxville, Tenn.

2:20 **Discussion**

2:40 **Engineering Aspects of the Influence of Forests on Mountain Streams** (with Lantern Slides)

RICHARD A. HERTZLER, *Jun. Am. Soc. C.E., Assistant Hydraulic Engineer, U. S. Forest Service, Appalachian Forest Experiment Station,* Asheville, N.C.

3:00 **Discussion opened by**

C. W. OKEY, *M. Am. Soc. C.E., Principal Engineer, General Engineering Division, Tennessee Valley Authority,* Knoxville, Tenn.

C. R. HURSH, *Senior Forest Ecologist, Appalachian Forest Experiment Station,* Asheville, N.C.

HERMAN STABLER, *M. Am. Soc. C.E., Chief, Conservation Branch, U. S. Geological Survey, Department of the Interior,* Washington, D.C.

3:25 **Recess**

3:30 **Observational versus Experimental Hydraulics**

GERARD H. MATTHES, *M. Am. Soc. C.E., Principal Engineer, Office of President, Mississippi River Commission,* Vicksburg, Miss.

3:45 **Discussion opened by**

C. H. EIFFERT, *M. Am. Soc. C.E., Chief Engineer and General Manager, The Miami Conservancy District,* Dayton, Ohio.

L. L. HIDINGER, *M. Am. Soc. C.E., President, Morgan Engineering Company,* Memphis, Tenn.

JOHN C. HOYT, *M. Am. Soc. C.E., Consulting Hydraulic Engineer, U. S. Geological Survey,* Washington, D.C.

C. H. PAUL, *M. Am. Soc. C.E., Consulting Engineer,* Dayton, Ohio.

3:55 **Performance of Norris Spillway and Stilling Basin** (with Moving Pictures)

A. J. PETERKA, *Junior Hydraulic Engineer, Tennessee Valley Authority,* Norris, Tenn.

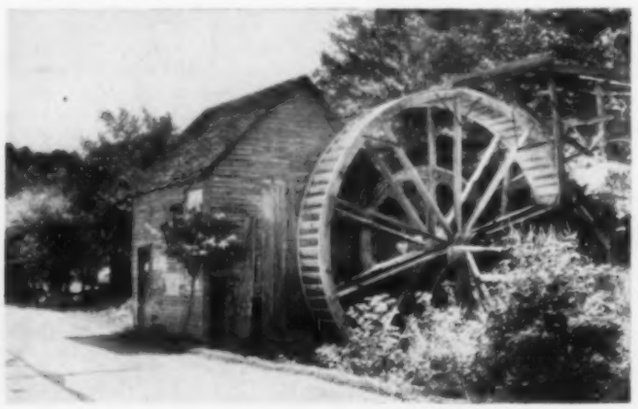
4:10 **Discussion opened by**

E. W. LANE, *M. Am. Soc. C.E., Associate Director in Charge, Iowa Institute of Hydraulic Research, University of Iowa,* Iowa City, Iowa.

F. M. DAWSON, *M. Am. Soc. C.E., Dean and Professor of Engineering, University of Iowa,* Iowa City, Iowa.

IVAN E. HOUK, *M. Am. Soc. C.E., Senior Engineer, U. S. Bureau of Reclamation,* Denver, Colo.

OCOEE DAM, TENNESSEE ELECTRIC POWER COMPANY



EARLY WATER POWER DEVELOPMENT

Sessions of Technical Divisions

THURSDAY—APRIL 20, 1939

POWER DIVISION

Afternoon

JOHN C. PAGE, *M. Am. Soc. C.E., Presiding*

SYMPOSIUM ON MASONRY DAMS

Sponsored by the following Divisions, represented by:

Construction Division	HARRY J. DEUTSCHBEIN
Irrigation Division	GLENN L. PARKER
Power Division	A. V. KARPOV
Soil Mechanics and Foundations Division	JAMES H. STRATTON
Structural Division	DUFF A. ABRAMS
Waterways Division	W. H. MCALPINE

During the last few years there have been a number of changes in design conceptions as applied to masonry dams. Probably three major influences are accountable for it:

1. The increased amount of engineering knowledge is responsible for the realization that the very simplified assumptions on which the design of dams have been based do not apply in their entirety, and that the design of safe and economical dams must be based on more refined design methods.

2. The considerable improvement in control, handling, and placing of concrete has made present-day masonry dams much more uniform, and eliminated to a large extent the uncertainties that were due in the past to non-uniform material.

3. As a result of the studies made in connection with arch dams, it has become clear that the properties of the foundations cannot be neglected if the behavior of an arch dam or a gravity dam is to be determined.

The work that is going on at present along these three major lines is being done by different men, different organizations, and often in different countries.

It would seem that all this widespread experience might well be made readily available by means of a carefully planned symposium. The immediate result would be to eliminate the theories that have no practical application at present, and to clarify the situation as to design data and theories that should be used and further developed in order to improve the design of masonry dams.

2:00 Introduction of the Chairman of the Symposium

WILLIAM P. CREAGER, *Chairman, Executive Committee, Power Division; M. Am. Soc. C.E., Consulting Engineer,* Buffalo, N.Y.

2:05 Opening Address

JOHN C. PAGE, *M. Am. Soc. C.E., Commissioner, U. S. Bureau of Reclamation,* Washington, D.C.

SESSION I

2:10 Masonry Dams—Basic Design Assumptions

IVAN E. HOUK, *M. Am. Soc. C.E., Senior Engineer, U. S. Bureau of Reclamation,* Denver, Colo., and KENNETH B. KEENER, *M. Am. Soc. C.E., Designing Engineer on Dams, U. S. Bureau of Reclamation,* Denver, Colo.

2:30 Discussion opened by

WILLIAM P. CREAGER, *M. Am. Soc. C.E., Consulting Engineer,* Buffalo, N.Y.

DUFF A. ABRAMS, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y.

P. E. GISIGER, *M. Am. Soc. C.E., Structural Engineer, Pennsylvania Water and Power Company and Safe Harbor Water Power Corporation,* Baltimore, Md.

GEORGE R. RICH, *M. Am. Soc. C.E., Head Mechanical Engineer, Tennessee Valley Authority,* Knoxville, Tenn.

3:10 Design of Gravity Dams

A. L. ALIN, *M. Am. Soc. C.E., Senior Engineer, U. S. Engineer Office,* Denison, Tex.

3:30 Discussion opened by

CECIL E. PEARCE, *Assoc. M. Am. Soc. C.E., Senior Hydraulic Engineer, Tennessee Valley Authority,* Knoxville, Tenn.

THOMAS H. WIGGIN, *M. Am. Soc. C.E., Consulting Engineer,* New York, N.Y.

H. A. KAMMER, *Assoc. M. Am. Soc. C.E., Assistant Design Engineer, American Gas and Electric Company,* New York, N.Y.

4:00 Design of Arch Dams

R. S. LIEURANCE, *Senior Engineer, U. S. Bureau of Reclamation,* Denver, Colo.

4:20 Discussion opened by

R. A. SUTHERLAND, *Assoc. M. Am. Soc. C.E., Hydraulic Designer, Central Nebraska Public Power and Irrigation District,* Hastings, Nebr.

GEORGE R. RICH, *M. Am. Soc. C.E., Head Mechanical Engineer, Tennessee Valley Authority,* Knoxville, Tenn.

4:40 Design of Special Dams

C. H. HOWELL, *M. Am. Soc. C.E., Construction Engineer, U. S. Bureau of Reclamation,* Denver, Colo.

5:00 Discussion opened by

C. V. DAVIS, *M. Am. Soc. C.E., Principal Planning Engineer, Tennessee Valley Authority,* Knoxville, Tenn.

JAMES P. GROWDON, *M. Am. Soc. C.E., Chief Hydraulic Engineer, Aluminum Company of America,* Pittsburgh, Pa.

Dinner and Dance at the Chattanooga Golf and Country Club

THURSDAY—April 20, 1939—Evening

7:00 P.M.

Following the dinner, there will be informal dancing and a floor show. Tickets for the dinner and evening's entertainment are $2.00 each. Tickets to students are $1.50 each. Tickets for the dance only are $1.00 per couple.

Sessions of Technical Divisions

FRIDAY—April 21, 1939—Morning

POWER DIVISION

JOHN C. PAGE, *M. Am. Soc. C.E., Presiding*

CONTINUATION OF SYMPOSIUM ON MASONRY DAMS

SESSION II

9:30 **Preparation of Foundations for Masonry Dams**

CHARLES H. PAUL, *M. Am. Soc. C.E., Consulting Engineer*, Dayton, Ohio, and JOSEPH JACOBS, *M. Am. Soc. C.E., Consulting Engineer*, Seattle, Wash.

9:50 **Discussion opened by**

ROSS M. RIEGEL, *M. Am. Soc. C.E., Head Civil Engineer, Design Department, Tennessee Valley Authority*, Knoxville, Tenn.

10:00 **Determination of Elastic Properties of Foundation Rock**

DR. R. K. BERNHARD, *Professor and Head of Department of Mechanics and Materials of Construction, The Pennsylvania State College*, State College, Pa.

10:15 **Discussion opened by**

ALDEN K. SIBLEY, *1st Lieutenant, Corps of Engineers, U.S.A., Assistant District Engineer, Conchas Dam*, N.Mex.

10:25 **Methods of Improving Foundation Rock**

JAMES B. HAYS, *M. Am. Soc. C.E., Construction Engineer, Chickamauga Dam, TVA*, Chattanooga, Tenn.

10:40 **Discussion opened by**

HANS KRAMER, *M. Am. Soc. C.E., Captain, Corps of Engineers, U.S.A., District Engineer, U. S. Engineer Office*, Conchas Dam, N.Mex.

J. D. LEWIN, *Assoc. M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

JAMES P. GROWDON, *M. Am. Soc. C.E., Chief Hydraulic Engineer, Aluminum Company of America*, Pittsburgh, Pa.

11:30 **General Discussion**

HIGHWAY DIVISION

L. G. HOLLERAN, *Chairman, Executive Committee, Presiding*

9:30 **Soil Stabilization in South Carolina**

W. H. MILLS, *Testing Engineer, State Highway Department*, Columbia, S.C.

10:00 **Discussion**

10:15 **Construction of Embankments Across TVA Reservoirs**

F. E. JUNIOR, *Assoc. M. Am. Soc. C.E., Highway Engineer, Tennessee Valley Authority*, Chattanooga, Tenn.

10:45 **Discussion**

11:00 **Low Cost Highway Construction in Alabama**

LEON GOTTLIEB, *Assoc. M. Am. Soc. C.E., Bituminous Engineer, State Highway Department*, Montgomery, Ala.

11:30 **Discussion**

CONSTRUCTION DIVISION

DANIEL T. WEBSTER, *Chairman, Executive Committee, Presiding*

9:30 **Time Studies and Cost Accounting on Large Construction Operations**

F. C. WARDWELL, *Assoc. M. Am. Soc. C.E., Senior Civil Engineer, Tennessee Valley Authority, Chickamauga Dam*, Chattanooga, Tenn.

10:00 **Discussion**

10:15 **Principles of Plant Layout for Large Dams**

R. T. COLBURN, *M. Am. Soc. C.E., Construction Plant Engineer, Tennessee Valley Authority*, Knoxville, Tenn.

10:45 **Discussion**

11:00 **Principles of Plant Layout for Buildings**

R. L. BERTIN, *M. Am. Soc. C.E., Chief Engineer, White Construction Company, Inc.*, New York, N.Y.

11:30 **Discussion**

Excursion to Chickamauga Dam, Friday Afternoon

The Excursion Will Leave the Hotel at 1:30 p.m.

Chickamauga Dam is one of the dams projected by the Tennessee Valley Authority across the Tennessee River to give a 9-ft channel from Knoxville to the Ohio River. It is about 8 miles above Chattanooga at the head of the Hale's Bar pool. Work was commenced in January 1936 and is scheduled for completion about June 1940. The structures across the main channel are of the concrete gravity type and consist of a navigation lock, spillway, and power house section. These are flanked on both sides of the river by earth embankments which extend across the flood plain to high ground. The total length of the dam, including earth embankments, will be approximately 5,794 ft. The top of all structures, exclusive of roadway, will be 108 ft above bedrock and the level of the Tennessee River will be raised 53 ft above the Hale's Bar pool.

The pool created by the dam will extend to the proposed Watts Bar Dam on the Tennessee River, a distance of 59 miles, and to Charleston, Tenn., on the Hiwassee River. The reservoir will cover 36,500 acres and the available storage for flood control will be 325,000 acre-ft. The length of the shore line, including islands, will be 500 miles. No charge for this trip.

PANORAMA OF CHICKAMAUGA DAM

Entertainment for the Ladies

WEDNESDAY—April 19, 1939

9:00 Registration

10:00 Ladies will be welcome at the Opening Session of the Spring Meeting

12:30 Luncheon

Ladies' luncheon at Fairyland Club.
Tickets $1.00 each.

2:00 Motor Trip to Lookout Mountain and Rock City

No charge.

Please register for this trip at the registration desk before 10:00 a.m.

Lookout Mountain, world-famous for its magnificent scenic panoramas, enshrined in the hearts of Americans as scene of one of war's most picturesque encounters—"The Battle Above the Clouds."

Lookout Mountain offers breath-taking views from many points, most renowned being the Moccasin Bend panorama from the point of the mountain which impelled Prince Henry of Prussia to exclaim in 1902, "There is nothing like it in all Europe."

Rock City is a natural wonder created by bizarre rock formations which take the forms of a city with great buildings, streets, and avenues. Adding to the work of Nature are swinging bridges and decorative features of various sorts. In the gardens are more than 400 varieties of native wild flowers and shrubs. The gardens are entered through a lodge constructed of mountain stone. Near the entrance is a bronze plaque awarded by the Garden Clubs of America.

Ruby Falls is in Lookout Mountain Caverns which are entered by an electric elevator which lowers the visitor 400 ft to the cave level. The waterfall is 145 ft high. Encountered at a sudden turn of the long underground corridor and illuminated by colored flood lights, it looks not unlike the setting for a scene in grand opera.

7:00 Dinner

Ladies will join members at dinner at the Hotel Patten.
Tickets $1.50 each.

THURSDAY—April 20, 1939

2:00 Motor Trip to Missonary Ridge, Fort Oglethorpe, and Chickamauga National Military Park

No charge.

Please register for this trip at the registration desk before 10:00 a.m.

This national park marks the battleground of Chickamauga, where the Confederates under General Bragg, after retiring from Murfreesboro and Tullahoma, closely followed by the Federals under General Rosecrans, turned and struck their pursuers, who had divided their forces in crossing the mountain ridges. On September 19 and 20, 1863, the Union forces were completely routed, except one division under General Thomas, which held out till evening and retired in good order. The rest of the Union army retreated in great disorder to Chattanooga, where they were beseiged and suffered great privation for two months. The battle of Chickamauga ranks third among all the encounters of the Civil War in percentage of casualties to total number engaged.

Twenty-nine states sent troops to take part in this engagement, of which four, Maryland, Kentucky, Missouri, and Tennessee, had troops with both the Blue and the Gray. Connecticut, Illinois, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania, West Virginia, and Wisconsin were represented in General Rosecrans' army, while Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas, and Virginia all had units with General Bragg.

7:00 Dinner and Dance

Ladies will join members at dinner and dance at the Chattanooga Golf and Country Club.
Tickets $2.00 each.

FRIDAY—April 21, 1939

1:30 Inspection Tour to Chickamauga Dam

Ladies will join members on this tour. No charge.

Please register for this trip at the registration desk before 10:00 a.m.

MISSIONARY RIDGE

Inspection Trips to Power Plants and to Points of Scenic Interest in East Tennessee and Western North Carolina

SATURDAY—April 22, 1939

Arrangements have been made for members and guests to visit the multiple-purpose dams of the Tennessee Valley Authority nearing completion at Chickamauga (near Chattanooga, Tenn.), Hiwassee (near Murphy, N.C.), and Guntersville (near Guntersville, Ala.), as well as the completed dams of the Tennessee Electric Power Company at Hale's Bar (18 miles below Chattanooga), Ocoee No. 1 and No. 2 (near Parksville, Tenn.), and the completed dams of the Aluminum Company of America on the Little Tennessee River, namely, Calderwood, Tenn., Santeetlah and Cheoah, N.C.

While the tours to the various dams will include views of scenic grandeur for which the mountains of East Tennessee and Western North Carolina have become famous, a special tour through a portion of the Great Smoky Mountains National Park has been arranged.

The following trips will start from the Hotel Patten at 9:00 a.m.:

Trip A—Tennessee Electric Power Company Dams, Ocoee No. 1 and No. 2, near Parksville, Tenn., and the TVA Hiwassee Dam near Murphy, N.C.

Trip B—Aluminum Company of America Dams on the Little Tennessee River

Trip C—Tennessee Electric Power Company Dam and Steam Plant at Hale's Bar, Tenn., and TVA Dam near Guntersville, Ala.

Trip D—Great Smoky Mountains National Park

Trip A—Tennessee Electric Power Company Dams, Ocoee No. 1 and No. 2, near Parksville, Tenn., and the TVA Hiwassee Dam near Murphy, N.C.

This tour offers a combination of beautiful scenery and interesting industrial developments. Leaving the Hotel Patten, the tour will follow U. S. 11 to Cleveland (32 miles), thence U. S. 64 to Parksville (13 miles). Just beyond Parksville, Ocoee No. 1, a storage dam 110 ft high with a reservoir of 80,120 acre-ft, and steam plant come into view. As the highway skirts the reservoir in its gradual climb through the foothills, interesting scenic views are unfolded. Eight miles from Ocoee No. 1 is the power house of Ocoee No. 2, fed by a wooden flume 5 miles long extending from Ocoee No. 2 on a grade of 0.064 per cent. This flume provides a head of 250 ft.

Attractive scenic views of the gorge of Ocoee River above Ocoee No. 1 are quickly followed by the unusual sight offered by the hills and gullies of the Ducktown-Copperhill area. The distance from Parksville to Ducktown is 27 miles. The highway on to Hiwassee Dam leads through the business section of Ducktown to Turtletown, Tenn. (8 miles), which is the railhead for the Hiwassee Dam. From Turtletown to Hiwassee Dam, a distance of 12 miles, the tour will travel on the TVA access road constructed for the dual purpose of providing a means for hauling supplies from the railhead to the dam and also to provide a permanent road to the dam from points in Tennessee.

Hiwassee, a storage dam 1,265 ft long, constructed entirely of concrete, will be the highest overflow straight gantry spillway type in the eastern half of the United States. When completed, it will be 321 ft high, approximately 60 ft higher than TVA's Norris Dam near Knoxville. It will have a reservoir of 435,000 acre-ft. Construction was started July 7, 1937. The dam closure is scheduled for February 1940, and the filling of the reservoir will be completed in July 1940.

Luncheon will be served at the TVA cafeteria at Hiwassee Dam. The return trip will be by the same route. The total distance is 180 miles. Tickets for this trip are $3.00 each.

Trip B—Aluminum Company of America Dams on the Little Tennessee River

This tour will leave the Hotel Patten, following U. S. 11 to Cleveland (32 miles). From Cleveland, the route will follow Tennessee Highways Nos. 60, 39, 33, and 72 to Calderwood Dam (73 miles). From Calderwood Dam, U. S. 129 leads to Tapoco Dam (24 miles). Lunch will be served at Tapoco Lodge. From Tapoco the same route is followed on to Santeetlah Dam (9 miles) and beyond to Murphy, N.C. (48 miles) and back to Chattanooga by U. S. 64 (90 miles). Total distance 276 miles, through some of the most beautiful scenery in the United States.

Tickets for this trip are $3.50 each.

Trip C—Tennessee Electric Power Company Dam and Steam Plant at Hale's Bar, Tenn., and TVA Dam near Guntersville, Ala.

Leaving the Hotel Patten, this tour follows U. S. 41 going west to four miles beyond Jasper, Tenn., the junction point with U. S. 72, a distance of 31 miles. The tour takes the visitor over the side of Lookout Mountain and through a beautiful rolling country. Eighteen miles from Chattanooga Hale's Bar Reservoir, Dam, and Steam Plant are to be seen. A short highway leads to the dam.

Hale's Bar Dam is 60 ft high and 2,500 ft long. Its reservoir extends to Chattanooga. After a visit to Hale's Bar Dam, the tour will continue on to Guntersville Dam over U. S. Highway 41 to the junction point beyond Jasper, and then over U. S. Highway No. 72 to Scottsboro, Ala., a distance of 26 miles. From Scottsboro the tour follows Alabama Highway 32 for a distance of 22 miles to the junction point of U. S. Highway 241 and Alabama Highway 30, and thence on to Guntersville via U. S. Highway 241, a distance of 4 miles. At Guntersville, the visitor will be interested in the new harbors, rail ferries, dikes, and other improvements made necessary as a result of the creation of the Guntersville Reservoir. Guntersville, an inland town, has been transformed into a port, surrounded on three sides by deep water. Leaving Guntersville on U. S. Highway 241, the tour leads to the TVA access road intersection. The access road, four miles in length, brings the visitor to the dam.

Guntersville Dam is of earth and concrete construction, 3,955 ft long and 94 ft high. The reservoir area is 951,000 acre-ft and extends 82 miles to Hale's Bar Dam.

Luncheon will be served at the TVA cafeteria at Guntersville Dam. The total length of the trip is 226 miles.

Tickets for this trip are $3.00 each.

Trip D—Great Smoky Mountain National Park

This tour will be made by chartered bus and will require a minimum of 25 passengers in order to secure minimum rates per passenger.

The tour will leave the Hotel Patten at 9:00 a.m. and will proceed via Maryville to Gatlinburg in the Great Smoky Mountains National Park. The night will be spent at Gatlinburg in one of the three available hotels. On Sunday morning the trip around the "Loop" will be made, including Clingman's Dome, Bald Eagle, Mount LeConte, and Pigeon River Forge and returning to Chattanooga. The total tour is 300 miles and the approximate charge for transportation only will be $3.00, provided 25 passengers are secured. Room and meals are additional. If the members wish, the bus will take them and their baggage into Asheville and leave them there, for approximately $1.50 more. No fixed arrangements have been made, as this tour can be varied to suit the wishes of those taking it. Those interested will register at the registration desk before 10:00 a.m., Thursday, April 20.

Accommodate the Local Committee by Registering and Obtaining Tickets Early

Hotel Accommodations and Announcements

In order to be certain of accommodations, members are urged to make definite arrangements for rooms at least a week in advance of the Spring Meeting, paying for the rooms in advance for at least part of the period for which they expect to be in Chattanooga.

The Hotel Patten is the meeting headquarters and, it is expected, will be able to care for all who attend.

Hotel Rates

Hotel	Single Rooms		Double Rooms	
	With Bath	Without Bath	With Bath	Without Bath
Patten	$2.50 up	$2.00	$4.00 up	$3.00 up
Northern	1.75	1.25	3.00	2.00
Read House	2.50 up	...	4.00 up	.....
Plaza	2.00 up	1.50	3.00 up	2.50
Ross	2.00	1.50	3.00	2.50
Walden	1.50	1.25	2.50 up	2.00
James	1.50	1.00	2.00	1.50
Park	2.00 up	...	3.00 up	.....

All who attend the Spring Meeting are requested to register immediately upon arrival at headquarters. Special badges and tickets will be obtained at the time of registration.

Local Sections Conference, Tuesday, April 18, 1939

A conference of representatives from Local Sections will be held on Tuesday, April 18, at 9:30 a.m. Accredited representatives from the 16 Local Sections in the Southern Meeting Region will discuss Local Section affairs. The conference is held under the sponsorship of the Southern Region Meetings Committee, of which C. M. Reppert, Vice-President, Am. Soc. C.E., is chairman. All members of the Society will be welcome to attend.

Order All Tickets in Advance

Members who order tickets in advance not only will be saved delay by having tickets and badges awaiting them on arrival at headquarters, but they will assist the Committee greatly by giving advance information to guide it in concluding arrangements.

Information

A registration desk will be provided in the headquarters hotel to assist visiting members in securing desired information about the city. At the registration desk a card file of those in attendance will be maintained, with information as to Chattanooga addresses.

Entertainment for the Ladies

Attention is directed to the entertainment provided for the ladies on Wednesday and Thursday. It is expected that they will participate with the members in any other features of the program in which they are interested.

Student Luncheon and Conference

Members of Student Chapters are invited to participate in all the events of the Spring Meeting. Particular attention is called to the Student Luncheon and Conference on Thursday, and to the special price for students for the Wednesday and Thursday evening functions.

Executive Committee

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J. I. PERREY, *Vice-Chairman*

JOHN F. BARKSDALE
H. L. FRUEND
ERWIN HARSCH
F. C. WARDWELL
W. H. WILSON

C. B. COE, *Executive Secretary-Treasurer*

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JAMES E. MORELAND, *Chairman*
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Power
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Construction
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CLIFFORD A. BETTS

Soil Mechanics and Foundations
JAMES B. HAYS, *Chairman*
JAMES S. LEWIS, JR.

Hydraulics
A. S. FRY, *Chairman*
SHERMAN M. WOODWARD

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E. F. CHOBOT, *Chairman*
F. C. WARDWELL, *Vice-Chairman*
R. H. BAKER
A. F. PORZELIUS
D. HEWITT WOOD

Entertainment
W. H. WILSON, *Chairman*
F. E. JUNIOR, *Vice-Chairman*
J. K. BLACK
R. E. FRIERSON
G. R. KAVANAGH
R. S. LILLARD

Reservations and Registration
H. M. TOWNSEND, *Chairman*
M. L. SHAHAN, *Vice-Chairman*
E. J. CONN
F. C. DUNHAM
J. E. HOCKER
H. JERVEY KELLEY

Reception Committee
D. HEWITT WOOD, *Chairman*
H. L. FRUEND, *Vice-Chairman*
C. E. BLEE
T. F. BOLTZ
E. D. BURCHARD
N. W. DOUGHERTY
G. B. EARNEST
A. S. FRY
R. S. GARRETT
V. GONGWER
J. P. GROWDON
JO CONN GUILD
H. H. HALE
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P. B. HILL
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O. LAURGAARD
C. E. MCCASHIN
G. H. MATTHES
O. J. MILLER
C. E. NICHOLS
R. F. OLDS
J. I. PERREY
A. F. PORZELIUS
W. H. RHODES
W. W. SANDERS
LEE G. WARREN

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MRS. JOHN F. BARKSDALE, *Vice-Chairman*
J. M. HAYES
C. C. MINER
V. D. L. ROBINSON, *Advisor*

Ladies Entertainment
MRS. J. E. MORELAND, *Chairman*
MRS. J. I. PERREY, *Vice-Chairman*
MRS. CLIFFORD A. BETTS
MRS. R. E. FRIERSON
MRS. H. JERVEY KELLY
MRS. A. F. PORZELIUS
MRS. NED H. SAYFORD
MRS. W. G. STROMQUIST
MRS. LEE G. WARREN
MRS. D. HEWITT WOOD

Exhibits
F. C. WARDWELL, *Chairman*
NORMAN F. WILLIAMS, *Vice-Chairman*
V. D. L. ROBINSON

Transportation
W. H. SEARS, *Chairman*
ERVIN F. NEWMAN, *Vice-Chairman*
EARL G. DOBBINS
W. N. DOWNEY
JAMES F. POU
GEORGE E. SCHMIDT

Ladies Reception Committee
MRS. LEE G. WARREN, *Chairman*
MRS. D. HEWITT WOOD, *Vice-Chairman*
MRS. C. E. BLEE
MRS. E. D. BURCHARD
MRS. H. L. FRUEND
MRS. A. S. FRY
MRS. P. B. HILL
MRS. J. L. LAMSON
MRS. O. LAURGAARD
MRS. O. J. MILLER
MRS. R. F. OLDS
MRS. T. B. PARKER
MRS. T. P. PENDLETON
MRS. SHERMAN M. WOODWARD

The program as a whole has been prepared under the direction of the Southern Region Meetings Committee, composed of C. M. REPPERT, *Vice-President Am. Soc. C.E., Chairman*; and JAMES A. ANDERSON, R. P. DAVIS, S. W. SAWIN, and T. KEITH LEGARÉ, *Directors Am. Soc. C.E.*

Please call on the Local Committee on Arrangements or on the Secretary's office for any service desired.

SOCIETY AFFAIRS

Official and Semi-Official

Program and Aims of the Hydraulics Division

Most recent addition to the Technical Divisions of the Society, the Hydraulics Division, was authorized by the Board of Direction in June 1938. The first Executive Committee of the Division was appointed by the Board in October 1938, and consists of Fred C. Scobey (chairman), Charles H. Paul, J. C. Stevens, Gerard H. Matthes, and Boris A. Bakhmeteff. Mr. Scobey has prepared the following statement for information of the membership at large.

THE Executive Committee of the Hydraulics Division held its first meeting in Dayton, Ohio, in December 1938. At that time the general program and aims of the Division were formulated, and since then sufficient progress has been made to enable the Division to schedule two technical sessions for the Spring Meeting of the Society at Chattanooga, a joint session and a session alone for the Annual Convention at San Francisco.

It has been decided that the former "Research Committees" now assigned to the Hydraulics Division will be continued for the present in the same form and with the same personnel as before—with the exception of the National Water Policy Committee, which was discharged by the Board of Direction at the suggestion of the chairman of that committee. It is likely that a new committee will be organized with functions that will more nearly fit a title of "Committee on Water Resources." The committees on Meteorological Data, Flood Control, Flood Protection Data, and Hydraulic Research have passed over smoothly from the old to the new status. The Committee on Flood Control is just completing its final report. After that, it is proposed to merge the functions of the two committees touching on floods into one "Committee on Floods." New committee work is in the formative stage.

The Executive Committee were unanimous in their agreement as to the type of programs to be offered the membership from time to time. For the near future it was agreed that "local-project" subjects should be accepted only when some feature of broad application could be accented. "General" subjects are preferred. The reading of long papers will be discouraged, with the thought that a short assembly of highlights from a paper, illustrated with moving pictures or slides, will be more acceptable for oral presentation. Discussion from the floor will be encouraged. The theory and mathematics of hydraulics will be acceptable for such programs only when they do not become so involved in detail that they are boring to an audience that comes to be entertained in an instructive way. On the other hand, suitable papers of any nature, submitted with illustrations or diagrams, will be passed upon with a view to printing in one of the Society publications. Thus papers will be reviewed for submission toward publication that would not be acceptable for convention programs. The Division proposes to encourage public appearance and papers by the younger members, the subject material being the main basis of consideration.

The Executive Committee agrees that applied hydraulics as well as theoretical investigation and analysis come within the field of the new Division. Likewise hydraulics is taken in its broader sense, to cover hydrostatics, hydraulics, and hydraulic engineering, with encouragement toward education of the civil engineering student in the modern fluid mechanics. Every assistance feasible will be given toward verifying performance in models with that in the prototype constructed along the lines developed in the model. In this connection the Committee wishes to encourage engineers in charge of design and construction of full-size structures to include facilities for hydraulic tests, in all cases where preliminary study was made in models. (Piezometer connections, it should be noted, are easily installed during construction but are difficult to place afterward.) Reports of model and prototype conformity—or lack of conformity—will be most acceptable. Where negative results can be explained, they may be more valuable than positive data.

Active cooperation will eventually be taken up with groups in other national societies, where hydraulics constitutes one phase of their major field.

"Tri-City Group" Organized to Serve Members in Rock Island-Moline-Davenport Area

MEMBERS of the Society residing in Rock Island and Moline, Ill., and Davenport and Muscatine, Iowa, perfected a temporary group organization at their second dinner meeting, held in Rock Island on March 10, 1939. Chairman of the group is J. E. Jewett. C. H. Young has been chosen as vice-chairman and T. J. Rodhouse as secretary. The ultimate objective of the group is to effect a permanent organization, as either a Sub-Section or a Section of the Society, "in order that the aims of the Society may be more completely carried out in these communities, which are so closely linked geographically, yet so far removed from the influence of the Sections [Illinois and Iowa] within whose jurisdiction they fall."

The concentration of engineering talent in the vicinity of the Tri-Cities has made possible this development. "In addition to the 9-ft channel canalization project now nearing completion on the Mississippi River," writes Mr. Rodhouse, "a new $2,250,000 highway bridge between Rock Island and Davenport is being started, and large sewer and water works improvement projects in both Rock Island and Davenport are under construction."

At the March 10 meeting it was decided to continue the organization on a temporary basis for a further periods of 90 days, to give time for straightening out the complications arising from the fact that the membership is drawn from territories served by two existing Sections. Meanwhile, monthly meetings of the group will be continued, with programs including papers by its own members and by guest speakers from the vicinity. Plans are also being made for a full-day meeting later in the spring, in which both the Illinois and the Iowa Sections will be invited to participate.

On the March 10 program were papers by two members of the Tri-City group. H. S. Smith, Jun. Am. Soc. C.E., gave a paper on "High-Rate Trickling Filters," which covered in some detail the differences in design, construction, first cost, and operating costs between the high-rate type trickling filter and the conventional-type filter in sewage treatment practice. The second paper was presented by L. A. Carlson, a civil engineer with the U. S. Engineer Office, Rock Island, Ill. His paper, entitled "Forecasting in Connection with Pool Operation," discussed a relatively new problem which has developed with the operation of a series of navigation dams such as is involved in the Upper Mississippi River canalization project. The accurate forecasting of inflows into each of the navigation pools 24 hours in advance, and the dispatching of the information to personnel at the 13 navigation dams now operated or about to be operated in the Rock Island Engineer District, have required detailed studies of the hydrology of the Mississippi River basin, as well as the organization of a complex system of dispatching reports on rainfall and stream-gage heights from key stations within the watersheds involved, to the forecasting office in Rock Island. Both the papers proved exceedingly interesting to the group.

It appears that much is to be gained by continuing a series of meetings of members of the Society in and near the Tri-Cities.

Pittsburgh Section Sets Up Service to Aid Employment of Juniors

TO PROVIDE a more ready means of contact between Juniors looking for engineering jobs and members of the Society needing engineers, a so-called "Contact Service" was recently organized by the Pittsburgh Section. J. W. McKnight, Chairman of the Junior Division of the Section, is in charge of the program.

As the result of a canvass of Juniors, a personnel record file has been developed, which includes both "active" and "inactive" cards, depending on whether a Junior is currently unemployed or temporarily employed. Information on the card includes such items as education, experience, type of work for which qualified, and date available. Concurrently, all members of the Pittsburgh

Section have been apprised of the plan and requested to notify the Contact Service in case they require help themselves or know of openings. When an opening develops, all men registered under that particular classification of engineering activity are notified by the Service, so that they may make direct application to the proper office.

There are no fees, the cost to each Junior being limited to supplying postage and envelopes for his notifications. Emphasis is placed on the fact that the Service is not an employment agency, but rather a "clearing house for information," and that it is strictly limited to members of the Pittsburgh Section.

Reprints from "Transactions"

WORK on the annual volume of TRANSACTIONS is progressing steadily at Society Headquarters, and Volume 104 will be collated and ready for distribution in time to include the paper-bound copies with the October issue of PROCEEDINGS. The first papers in the volume have already been prepared and are being sent to press.

The Society's policy regarding the distribution of reprints is as follows. Reprints of PROCEEDINGS papers are never provided except to fill special orders of 100 or more. When a paper, with all discussions and the closure, has been collated and printed in TRANSACTIONS, the author is presented with 25 copies of the complete paper and each discusser receives two reprints. A limited supply is placed in stock for single-copy sale. Any members who may need quantities of 100 or more will profit by placing their orders on file before the type is removed from the presses after the regular edition has been run. For these reprints, and for similar standard reprints of PROCEEDINGS, prices can be quoted approximately as follows:

NUMBER OF PAGES	100 COPIES	ADDITIONAL 100 COPIES	NUMBER OF PAGES	100 COPIES	ADDITIONAL 100 COPIES
4	$7.00	$2.50	24	$15.50	$3.75
8	8.75	2.75	32	18.75	5.75
12	11.50	3.25	48	22.00	5.75
16	11.75	3.50	64	29.00	6.50
20	14.50	3.50	80	30.25	7.00

Prices are subject to change without notice.

After the regular edition has been run, the added cost of placing type matter back on the presses increases the cost of reprints materially. Orders should therefore be placed early, with the understanding that the actual cost will be based on bills received from the printer.

Notable Mid-Winter Gathering of Engineering Institute of Canada at Ottawa

TO ATTEND the 53d annual meeting of the Engineering Institute of Canada, a large group of engineers and others met in Ottawa, Ontario, commencing February 14, 1939. The northern latitude and mid-winter climate seemed to have no adverse effect on the size or enthusiasm of the sessions; in fact, the commodious facilities of the Chateau Laurier gave a sense of comfort and welcome that typified the whole meeting.

As far as Canadian engineers were concerned, it was a national gathering, but in fact it was more than that, because the presence of guests and non-members lent an international atmosphere. Societies south of the border were generously represented, with the president and secretary of the American Society of Civil Engineers as well as those of the Mechanical and Electrical societies, including the wives of these officers. Another honored guest was the chairman of the Engineers' Council for Professional Development.

One particular session, on the afternoon of the opening day, Tuesday, February 14, was devoted to the recognition of these visitors. This function, similar to the other sessions of the meeting, was conducted with a dignity and precision which went beyond a mere welcome to give at the same time a warm feeling of professional and international solidarity. The presidents and secretaries of the visiting organizations were individually introduced and responded, touching upon various topics.

A fine treat was in store for the same evening, when the annual dinner of the Institute was held. This formal event was noteworthy in a number of ways, but particularly in the presence of Their Excellencies, the Governor General and Lady Tweedsmuir. This signal event not only emphasized the high standing of the profession throughout the Dominion but gave an opportunity for a demonstration of the deep affection felt for Their Excellencies and for their official status in Canada. Again the gift of organization of social events and the dignity of the Canadian professional man was emphasized. The meeting was all that such an event should be in its ideal form. It was further noteworthy in that the principal address was delivered by Willard Chevalier, M. Am. Soc. C.E.

While speaking of social matters, mention should be made of the ladies' tea held on Wednesday afternoon at Government House, official residence of the Governor General. Her Excellency, Lady Tweedsmuir, graciously received a large group of the visiting ladies.

Professional papers were confined to the sessions on Wednesday, February 15. In all, eleven papers were presented, diversified so as to give an insight into a variety of technical problems scattered over the Dominion but centering more particularly on those of mid-west Canada. In between the morning and afternoon sessions of each day a delightful lunch was arranged, with greetings by Dominion officials and interesting and informative talks by selected speakers.

Finally, an informal social event on Wednesday evening completed this annual meeting of the Institute. To say that the entire affair was most interesting is putting the matter very mildly. From the standpoint of the visitors from the United States, it was a delightful experience. The hospitality of their Canadian brethren was both genuine and complete. This meeting therefore presented still another evidence of the warm ties which bind the professions in the two countries. It also gave an opportunity for returning similar courtesies that have been so generously rendered by Canadian engineers in their attendance at meetings held south of that invisible international boundary.

Committee of Cleveland Section Maps Many Worth While Objectives

CURRENTLY at work in the Cleveland Section is a Special Committee on Aims and Objectives, which is studying possible fields of activity "that might lend new interest and strength to the work of the Cleveland membership." Its recent progress report contains a wide variety of suggestions that should prove of value to Local Sections in all parts of the country. A number of these suggestions are abstracted in the following paragraphs:

"*Vocational Guidance.* Advertising released by manufacturers has a large influence on the selection of technical work undertaken in the colleges. Advertising of this character has played up aeronautical engineering, electrical engineering, chemical engineering, mechanical engineering, but not civil engineering. It is important for the future of the profession that we continue to secure young men of excellent caliber in civil engineering. The Committee proposes that this Section cooperate with the local high schools, many of which already have vocational guidance programs, on vocational guidance in civil engineering.

"*Higher Education and Graduate Study.* We believe that it is the business of the Society and of this Section to interest and inform itself on higher education for civil engineers. In various schools throughout the country the program of graduate study is larger than most people realize. The significance and importance of graduate study should be a matter on which all civil engineers, and particularly the younger men, should be informed. The Committee suggests that the Cleveland Section acquaint itself with higher education for civil engineers, either by papers at stated intervals, or through a periodical report.

"*Status of the Junior Members.* It is well recognized that heretofore the Junior members have been spectators and not participants. The Committee recommends that the Juniors be made responsible for one of the monthly programs each year and that the spring meeting organized by the Student members be continued as before.

"*The Recognition of the Civil Engineer Before the Public.* We believe that definite steps should be taken to promote recognition of

the civil engineer before the public. Within limits, this can be done as before by publicity given to meetings of the Society. The Committee has also discussed the possibility of a meeting open to the public. The suggested program of this meeting would be a forum in which four or five speakers would hold forth for perhaps 10 or 15 minute intervals, on subjects which would be interrelated to show the developments in the Cleveland area in which the civil engineer has played a leading rôle.

"*Recognition Within the Profession*. The Committee feels that the Section may properly consider the matter of making awards for recognition by the Local Section of members in various grades for attainment. For example:

Certificate of merit to the most active Junior in the Section each year.

Certificate of merit to be given each year to the paper of outstanding merit presented before the Society by members of the Cleveland Section.

Bi-annual award of suitable character for outstanding public service within the field of civil engineering to a member of the Cleveland Section.

"*Social Activities*. The American Society of Mechanical Engineers in Cleveland has a Ladies' Guild which is quite active, and which underwrites a tuition scholarship in mechanical engineering. The Cleveland Section of the American Society of Civil Engineers might well consider a social program which would include the ladies at least once a year.

"*Relations with Neighboring Sections*. The Cleveland Section has already initiated a plan of 'Ohio Regional Meetings,' and two such meetings have already been held. Another one is now suggested, centering around some project of sufficient importance and general interest to warrant a large attendance. We believe this is a well worth while project and should be undertaken. On the occasion of such a meeting the matter of a state council of the various sections in Ohio might well be taken up."

It should be emphasized that these quotations are from a progress report, which the Committee has circulated among members of the Cleveland Section for discussion. None of the suggestions has as yet been officially adopted.

Texas Section Cultivates Juniors

ONE OF THE characteristics for which the Texas Section is notable is its custom of holding two two-day meetings each year in place of the bi-weekly or monthly meetings held by Sections in more restricted areas. As a result of this type of meeting with six-month intervals between, many of its activities have been pitched to a tempo different from that of other Sections. Recently Secretary Focht of the Texas Section offered some helpful suggestions to the Section's Committees on Juniors and Student Chapters, certain extracts from which will be of interest to the officers of other Local Sections.

How to hold and increase the interest of the Junior in the Section and in the Society is quite a problem, says Professor Focht. As a rule these young engineers find it very difficult to get away from their work to attend the meetings of the Texas Section. Also, they feel a hesitancy in talking and visiting with the older engineers. He suggested that personal invitations be extended to the Juniors, and especially those residing in the immediate area, to attend the semi-annual meetings of the Section. Further, a special effort should be made to locate the Juniors as they attend the meetings and introduce them to the older members of the Society, thus making them feel more at home. It is natural for the older men to spend a great deal of time with old friends. However, if a Junior met them at two or three meetings, he would soon pass into the same category of friendship.

A special effort might also be made to interest several Juniors in preparing papers for the meetings of the Texas Section. It might be feasible to hold a separate session for the Juniors, or perhaps a session sponsored by Juniors entirely.

As far as members of the Student Chapters are concerned, Professor Focht suggested that additional recognition be accorded, beyond that given previously, by having each one stand and give his name. For one thing, it might be possible to arrange a breakfast meeting some morning for members of Student Chapters, at which some of the Section's board of directors and other Society members might be present. This modification may be found feasible at some future meeting of the Texas Section.

Some of these suggestions may fit in with the interests of other Sections. Although the details would vary with local conditions, the basic principle remains—that the younger member is worth encouraging and that the initiative naturally rests with the Section officials or senior members. The corollary is that such efforts doubtless will be many times repaid in the constructive interest of the Juniors and the resulting benefit to the Section itself.

New Year Book to Be Distributed with April "Proceedings"

ISSUED as Part 2 of PROCEEDINGS, the 1939 Year Book of the Society will be mailed to the membership on April 15. As in previous years, it incorporates all corrections in position and address reported by members up to the first of March. Incidentally, as reflecting the growth of the Society, there are 400 more names in this year's "List of Members" than in the 1938 edition.

In format and arrangement, the new book follows the style of the preceding issues. The policy adopted in 1938 of including in the Year Book the Annual Report of the Board of Direction has been continued. Attention should also be called to the somewhat extensive changes in the By-Laws—the result of a series of Board actions during 1938 and at the 1939 Annual Meeting.

Papers Filed in Library

ANNOUNCEMENT is made that the following papers have been contributed to the Society for filing with the Engineering Societies Library, 29 West 39th Street, New York, N.Y. Charges for photostating will be quoted by the Library on request.

BEAMS ON SOIL FOUNDATIONS

BOBISCH, WILLIAM J., Jun. Am. Soc. C.E., and BIRKELAND, H. W., Jun. Am. Soc. C.E., "Finite Beams on Elastic Soil Foundations, with Special Applications" (54 pages in mimeograph, including 25 diagrams). This paper proposes to present a rational method for the design of flexible footings. The analysis assumes that the problem is a two-dimensional one; that the foundation is elastic, with deformation proportional to pressure; and that shear deformation in the footing can be neglected.

SOLUTION OF RIGID FRAMES

DODGE, ALEXANDER, "Solution of Rigid Frames by Coefficients of Unit Moment" (33 typewritten pages and 5 pages of diagrams). This paper (copyright 1938 by the author) is intended "to give a quick and exact method of analysis of rigid frames which can easily be applied for construction of influence lines.... The method is based on the second principle of the moment area method." In addition to the derivation, the paper contains numerous examples worked out in detail.

Appointments of Society Representatives

GEORGE S. DAVISON, Hon. M. Am. Soc. C.E., has been appointed one of the Society's representatives on the John Fritz Medal Board of Award, to fill the vacancy caused by the death of Past-President, LOUIS C. HILL, whose term would have expired in October 1941.

KARL R. KENNISON, M. Am. Soc. C.E., has been appointed a member of the J. Waldo Smith Research Fellowship Committee, to fill the vacancy caused by the death of FRANK E. WINSOR.

MAURICE N. QUADE, Assoc. M. Am. Soc. C.E., will represent the Society on the Sectional Committee on Building Code Requirements for Signs and Billboards of the American Standards Association.

DONALD H. SAWYER, President Am. Soc. C.E.; W. H. CONNELL, BENJAMIN FRANKLIN, H. H. QUIMBY, and SOLOMON M. SWAAB, Members Am. Soc. C.E.; and GEORGE T. SEABURY, Secretary Am. Soc. C.E., were appointed to represent the Society at the "1939 Transportation Symposium" held by the Franklin Institute in Philadelphia on February 7.

The J. Waldo Smith Fellowship

Utilization of the proceeds of funds bequeathed to the Society by the late J. Waldo Smith, Hon. Am. M. Soc. C.E., will begin in the fall of this year with the award of the first J. Waldo Smith Fellowship in Hydraulics. Rules governing the award, as set up by the committee appointed to administer it, are presented below. The committee consists of Thaddeus Merriman (chairman), C. M. Allen, and Karl R. Kennison.

The J. Waldo Smith Fellowship in Hydraulics is available for the year September 1, 1939, to September 1, 1940. This Fellowship carries $1,000, of which $600 is the stipend of the Fellow with as much as necessary of $400 to cover the cost of materials and equipment to the laboratory where he is located. These materials and equipment will become the property of the laboratory at the end of the Fellowship term.

This fellowship is limited to those Universities and Colleges (hereinafter called Institutions) at which a Student Chapter of the American Society of Civil Engineers is established. The Fellow must be between 21 and 27 years of age and be a Junior of the Society; he must be recommended and sponsored as hereinafter provided.

Applications for this Fellowship should be addressed to the Secretary of the Society by the appropriate officer or Head of the Department of Engineering who should submit the names, records, and photographs of the candidate or candidates he recommends and sponsors. The application should also be accompanied by a statement describing the laboratory facilities available in sufficient detail to govern the Committee in its decision.

The Fellow must devote at least one half of the entire Fellowship year to the problem which the Committee will assign. The remainder of his time may be devoted to securing collegiate credits, and the time devoted to the assigned problem may be counted as he may arrange with the Institution. Just before the end of the Fellowship year, the Fellow shall submit to the Committee a complete report, analysis, and discussion of his work. This report may also serve as his thesis and may be published in whole or in part, with appropriate acknowledgments approved by all parties, including the Fellow, the Institution, and the Society.

As above indicated, it is the intention that the Committee shall select for this award both the Fellow and the Institution, emphasis being placed primarily on the qualifications of the Fellow including his record, his qualifications, and his promise for the future. Due but not controlling consideration will also be given to the equipment and facilities available at the Institution.

This Fellowship is restricted to study in the field of practical hydraulics as distinguished from the purely theoretical approach. To this end, emphasis will be placed on experiments designed to further knowledge of the laws of hydraulic flow rather than to the type of research which proceeds with mathematical analyses on the basis of premises of unknown validity. The essence of this procedure is to test current assumptions and to develop a better understanding of hydraulic flow in general. This line of approach was a characteristic of the great success of the founder of this Fellowship whose generosity has made it available. It is thus appropriate that the methods he followed should be developed and extended.

The Committee now considers that the first problem assigned will be that stated below but will be glad to receive suggestions of other problems which may be submitted with the application.

Problem. The determination by direct measurement of the differences in the resistance to the flow of water in smooth pipes which are (*a*) horizontal, (*b*) inclined, and (*c*) vertical. The pipes should range from $\frac{1}{2}$ to 4 in. in diameter and be of appropriate lengths, with velocities from 1 to 10 or more feet per second. The pipes should be of brass and the same pipes should preferably be tested in all positions without dismantling and reassembly.

This problem is one of fundamental importance in a field which, to this time, has remained unexplored. Its development may lead to concepts of value and to better interpretation of the great mass of data respecting hydraulic flow which is now available in the literature.

No applications will be received after June 1, 1939, and the award will be made as soon thereafter as possible. The Committee is empowered to reject any or all applications.

Past-President Mead Receives Washington Award

SOME 400 persons attended the dinner in Chicago on February 20 at which Daniel W. Mead, Past-President and Honorary Member of the Society, was presented with the Washington Award for 1939. Representatives of the Western Society of Engineers, which administers the award, and of the four Founder Societies, delivered

THE
WASHINGTON AWARD
IN RECOGNITION OF
PRE-EMINENT SERVICE IN
ADVANCING HUMAN PROGRESS
CONFERRED IN 1939 UPON
DANIEL · WEBSTER · MEAD
FOR HIS SUPERIOR CONTRIBUTION TO
SOUND THEORY GOOD PRACTICE AND
HIGH ETHICAL STANDARDS IN THE
CREATION OF ENGINEERING WORKS
AS AN ENGINEER AND AS A TEACHER
AWARDED BY THE
WESTERN SOCIETY OF ENGINEERS
ON THE RECOMMENDATION OF
AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGRS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
WESTERN SOCIETY OF ENGINEERS
MCMXXXIX

THE WASHINGTON AWARD PLAQUE PRESENTED TO DANIEL W. MEAD

brief congratulatory addresses, and Dr. Mead responded with an extempore address on the subject, "Fifty Years of Engineering Development."

"The occasion," writes Alonzo J. Hammond, the Society's representative, "was a very happy one—like a big family affair. Numerous graduates of the University of Wisconsin were present, and at the opportune time they gave their college yell for 'Danny Mead.'"

Dr. Mead, sixteenth recipient of the award, is the fifth civil engineer to be thus honored. His selection was announced in the February issue of CIVIL ENGINEERING.

In and About the Society

"THE ENGINEEROGRAM," newsbulletin of the Sacramento Section, made its first appearance in March. A project of the Section's publicity committee, it replaces the monthly postcard announcement of meetings and is designed to contain personal notes and many additional items of interest as well. It is an attractive four-page, printed publication.

* * * *

ATTENDANCE at 46 of the 50 Annual Meetings since he became a member is the resord of Herbert C. Keith. Are there other members with a greater number to their credit?

American Engineering Council

The Washington Embassy for Engineers, the National Representative of a Large Number of National, State, and Local Engineering Societies in 40 States

GOVERNMENT REORGANIZATION

Engineers have a double interest in the question of reorganization of the federal government. They recognize the eventual necessity of a balanced budget viewpoint in the federal government, and secondly, they believe that government expenditures for public works could best be managed from a policy and efficiency point of view if the various agencies which concern themselves with the many divisions and sections of public works were brought together under one administrative head. Budget balancing and government reorganization are being joined in the present discussion.

During the several A.E.C. forum discussions on employment, on invention, on government planning, and on government reorganization, three fundamental principles have emerged which, while they were not expressed as an official platform for engineers, nevertheless may be said to represent the majority opinion of the groups discussing the four topics. These conclusions may be put briefly as: (1) the need of a clearer government fiscal policy; (2) the hope for more efficient management by coordination and consolidation of present agencies into a simplified and responsible administrative organization of the government; (3) the need of divorcing administrative personnel from politics and the establishment of engineering professional and management services in the government on the merit system under a non-partisan Civil Service guidance.

Three bills on federal reorganization are now before the federal Congress. The first is the Byrnes Bill (S. 1265) which associates public works, either as a department or a division, with social security and is an attempt to merge the PWA and the WPA into some sort of a public works department. The second is the so-called Cochran Bill (H.R. 4425), which gives the President power to reorganize the government with the approval of Congress. This essentially is the bill which failed of passage last year because of controversial elements, most of which have been removed in the new bill. A third bill, introduced by Senator Byrd (S. 1706), provides for presidential reorganization of government departments, eliminates the six presidential assistants, and compels congressional vote on proposals within twenty days.

By far the most interesting contribution to this discussion is the factual report released by the Brookings Institution in a 275-page volume. The gist of this report is that the possibilities of economy through structural reorganization of federal administrative agencies are relatively minor in comparison with those which might be realized by the elimination and curtailment of activities.

STAFF AND COMMITTEE ACTIVITIES

Professor John S. Dodds, chairman of the A.E.C. Committee on Surveys and Maps, has been appointed by President McClellan, with the approval of the A.E.C. Executive Committee, as a member of the Advisory Council of the Federal Board of Surveys and Maps.

To further a program for mapping, a letter is being mailed to all the secretaries of the member organizations of Council, urging them to make reports expressing the needs of their societies for maps, and submit such reports to the Federal Board of Surveys and Maps, with copies to Professor Dodds. The Executive Secretary of American Engineering Council has been invited to attend a meeting of the Federal Board of Surveys and Maps on March 14, and speak on the desirability of a mapping program and the relation of American Engineering Council to it.

Washington, D.C.
March 7, 1939

News of Local Sections

Scheduled Meetings

CLEVELAND SECTION—Luncheon meeting at the Guildhall on April 4.

COLORADO SECTION—Dinner meeting at the University Club, Denver, on April 10, at 6:30 p.m.

DAYTON SECTION—Luncheon meeting at the Dayton Engineers Club on April 17, at 12:15 p.m.

DISTRICT OF COLUMBIA SECTION—Joint meeting with the Washington Society of Engineers (probably at the Chamber of Commerce of the United States) on April 18, at 8:15 p.m.

GEORGIA SECTION—Luncheon meeting at the Atlanta Athletic Club on April 10, at 12:30 p.m.

KANSAS CITY SECTION—Dinner meeting at the University Club on April 14, at 6:30 p.m.

KANSAS STATE SECTION—Dinner meeting with the Kansas State College and University of Kansas Student Chapters at Manhattan, Kans., on April 20, at 6:30 p.m.

LEHIGH VALLEY SECTION—Meeting at Easton, Pa., on April 28.

LOS ANGELES SECTION—Dinner meeting at the University Club on April 12, at 6:30 p.m.

METROPOLITAN SECTION—Technical meeting in the Engineering Societies Building, New York City, April 19, at 8:00 p.m.

MIAMI SECTION—Dinner meeting (probably in Palm Beach) on April 6.

NORTH CAROLINA SECTION—Annual meeting at the Carolina Hotel, Pinehurst, on April 29.

NORTHWESTERN SECTION—Regular meeting on April 3.

SACRAMENTO SECTION—Regular luncheon meetings at the Elks Club every Tuesday at 12:10 p.m.

ST. LOUIS SECTION—Luncheon meeting at the Mayfair Hotel on April 24, at 12:15 p.m.

SAN FRANCISCO SECTION—Dinner meeting at the Engineers Club on April 18, at 5:30 p.m.

SEATTLE SECTION—Dinner meeting at the Meany Hotel, Seattle, on April 28 at 6:30 p.m. (Joint meeting of the Tacoma and Seattle Sections with the Pacific and Northwest Conference of Student Chapters—O.S.C., M.S.C., U. of I., W.S.C., and U. of W.)

TEXAS SECTION—Spring meeting at Corpus Christi on April 28 and 29.

Recent Activities

CENTRAL OHIO SECTION—*Columbus, February 16:* Following a business meeting, C. C. Chambers, chief engineer of the Muskingum Watershed Conservancy District, discussed the difficulties that were encountered and overcome in the construction of the flood control works of the District—the largest project of its kind in the world. Unanimous approval was given to President Tolles' plan for a Local Sections conference to discuss the Progress Report on Salaries published in CIVIL ENGINEERING.

CINCINNATI SECTION—*February 24:* A joint meeting with the Technical and Scientific Societies of Cincinnati. Prior to the meeting there was a dinner in honor of the guest speaker, Hugh H. Clegg, assistant director of the Federal Bureau of Investigation, U. S. Department of Justice. The officers for 1939 are William W. Carlton, president; Rupert A. Anderegg, vice-president; and Raymond W. Renn, secretary-treasurer.

CLEVELAND SECTION—*March 7:* "The Cleveland Regional Geodetic Survey, with Observations on National Surveying and Mapping" was the subject of the lecture. This was given by A. J. Sweet, director of the Cleveland Regional Geodetic Survey.

COLORADO SECTION—*Denver, February 13:* Mr. McCrary, construction engineer for the State Planning Commission, gave an

interesting talk on the value and need of planning, suggesting solutions for the problems arising from urban growth and development. A colored motion picture, showing the results of unrestricted growth as compared with regulated development, concluded the evening. *Junior Association—October 31* and *November 28:* At the first of these sessions Commander Charles M. Johnson described U.S.S. ARD 1, the world's largest mobile floating dry dock. Speakers at the November meeting were Prof. William S. Bernard, of the University of Colorado, and Alvin Hanson, head of the Denver chapter of the Federation of Architects, Engineers, Chemists, and Technicians. Professor Bernard's subject was "Group Action for Improving the Economic Welfare of Engineers," while Mr. Hanson discussed the aims and purposes of the Federation.

DAYTON SECTION—*February 20*: Prof. J. R. Shank, assistant director of the Engineering Experiment Station at Ohio State University, came from Columbus to speak on the "Plastic Flow of Concrete." Wide interest in his experiments was attested by the unusually large attendance.

DULUTH SECTION—*January 16:* A business meeting followed luncheon. The current controversy over designs for a sewage disposal plant for Duluth was discussed, but no action was taken. W. H. Woodbury is the new president of the Section, and William E. Hawley will continue as secretary.

FLORIDA SECTION—*February 14:* Joint meeting with the Northeast Florida Association of Registered Engineers and Land Surveyors for the purpose of discussing changes in the Florida registration laws.

GEORGIA SECTION—*Atlanta, February 13:* The principal speaker was Stanley H. Wright, regional engineer for Region 3 of the Public Works Administration, whose subject was "Contrasting the Fundamentals Underlying British and American Humor."

HAWAII SECTION—*Honolulu, January 24:* Dr. William K. Hatt, emeritus professor of civil engineering at Purdue University, was the guest of the Section and gave a brief talk. A special committee, consisting of L. J. Watson, A. L. Marks, and E. L. Hageman, presented a verbal report on the status of engineers, as compared with other professional men, in public service. Considerable discussion followed the report.

INDIANA SECTION—*Indianapolis, February 11:* Annual meeting in conjunction with all-day session of the Indiana Engineering Council. Special features included the presentation of the Prize for Juniors, given for the first time this year by the Section. This award went to Rudard Jones, for his paper on "Some Early Notes on Arch Construction." At the dinner meeting that concluded the session Field Secretary Jessup was in charge of the ceremony of presenting life certificates. The principal speaker at the dinner meeting was Col. Chester Lichtenberg, who discussed the effects of military mobilization on American industry. Results of the annual election of officers held at this time were as follows: Fred Kellam, president; J. E. Hall, vice-president; and Denzil Doggett, secretary.

IOWA SECTION—*Des Moines, February 14:* Two Directors—T. R. Agg and W. W. De Berard—were present and discussed the Report of the Society's Committee on Salaries. Comments on the Annual Meeting were presented by L. O. Stewart, F. M. Dawson, J. S. Dodds, Charles Looney, and C. M. Stanley. Announcement of the Iowa Section awards of Junior membership in the Society—to Jack Clapsaddle and Marion Thorne—was made, and a technical program concluded the meeting. The speaker on the latter was O. W. Crowley, executive secretary of the Central Branch of the Associated General Contractors of America, who discussed "The Engineer in Construction."

ITHACA SECTION—*February 28:* An illustrated lecture on the work of the Water Resources Branch of the U. S. Geological Survey was given by Arthur W. Harrington, district engineer for the Survey and Director of the Society. Preceding the meeting, there was a dinner on the campus of Cornell University, and the Cornell Student Chapter served refreshments after the lecture.

KANSAS CITY SECTION—*February 24:* A reception and dinner in honor of Director Agg, the guest speaker, initiated the program. Dean Agg discussed the affairs of the Society in general and then gave a talk on the subject of the unionization of the engineering profession. A vigorous discussion of unionization concluded the program.

KANSAS STATE SECTION—*Topeka, February 10:* A business session followed a luncheon. Numerous matters of interest to the Section were discussed, and new officers were elected. These are M. W. Furr, president; F. W. Epps, vice-president; and George W. Lamb, secretary-treasurer.

LEHIGH VALLEY SECTION—*Bethlehem, Pa., February 28:* This joint meeting with the Philadelphia section of the American Welding Society was addressed by F. H. Frankland, chief engineer of the American Institute of Steel Construction. Mr. Frankland's topic was welding in the structural field, and his remarks were followed by a motion picture entitled "The Backbone of Progress."

LOS ANGELES SECTION—*February 8:* The principal speaker was R. V. Labarre, consulting foundation engineer, who described the effect of local aggregates on the durability of concrete. Those discussing the paper were L. H. Tuthill and R. M. Beanfield. At the conclusion of the evening a plaque was presented to A. M. Rawn, former president of the Section, in commemoration of his services in that capacity.

MARYLAND SECTION—*Baltimore, January 27:* Joint meeting with the Engineers Club of Baltimore. The session was devoted to a discussion of registration of professional engineers and land surveyors in Maryland.

METROPOLITAN SECTION—*New York City, February 15:* A symposium on "Engineering the New York World's Fair" was presented by the Section and collaborating groups—the New York section of the American Institute of Electrical Engineers and the New York Society of Municipal Engineers. The Section was represented among the speakers by H. Alden Foster, acting chief engineer of design for the New York World's Fair, and Alfred Hedefine, engineer with Waddell and Hardesty. *Junior Branch—February 8:* Harold E. Wessman,

Forecast for April "Proceedings"

PROPOSED IMPROVEMENTS FOR LAND SURVEYS AND TITLE TRANSFERS

By Philip Kissam, Assoc. M. Am. Soc. C.E.

State coordinates, official records, and land court to replace outmoded deleterious practice.

HYDROLOGY OF THE GREAT LAKES—A SYMPOSIUM

TYPICAL QUANTITATIVE ANALYSIS AS APPLIED TO LAKE SUPERIOR

By C. R. Pettis, M. Am. Soc. C.E.

Defines the relationship between rainfall and Lake levels, in the belief that the contribution of underground water is appreciable.

EVAPORATION EXPERIMENTS

By H. C. Hickman, Jun. Am. Soc. C.E.

Derivation of characteristic curves from experiments on evaporation pans for the purpose of determining comparable evaporation from the Great Lakes.

RECONSTRUCTION OF A STEEL ARCH BRIDGE

By H. E. Langley and Edward J. Dacey

Pertains to the ingenious repair methods applied to the 540-ft steel arch over the Connecticut River between Walpole, N.H., and Bellows Falls, Vt.

DESIGN OF A HIGH-HEAD SIPHON SPILLWAY

By Elmer Rock, Jun. Am. Soc. C.E.

Directions for designing adequate cross-sectional area at the throat, and a reduced outlet area, so that a definite spillway capacity can be provided.

STRESS DISTRIBUTION AROUND A TUNNEL

By Raymond D. Mindlin, Jun. Am. Soc. C.E.

Derivation based on the theory of elasticity.

professor of structural engineering at New York University, presented a method of rapid analysis and preliminary design of suspension bridges that he and Shortridge Hardesty had developed. This was the first of a series of lecture meetings presenting original contributions to the fund of engineering knowledge.

MICHIGAN SECTION—*Detroit, February 17:* Frederick P. Dillon, superintendent of lighthouses for the U. S. Lighthouse Service, was the speaker of the evening. His talk on the Lighthouse Service was enlivened by a stereopticon trip through his district. A social hour followed the meeting.

NASHVILLE SECTION—*February 7:* The regular bimonthly technical meeting was preceded by a dinner. Later in the evening the Vanderbilt University Student Chapter met with the members of the Section to hear Lee Warren, engineer for the Tennessee Valley Authority, speak on the construction of Chickamauga Dam, with particular reference to foundation problems.

NEW MEXICO SECTION—*Santa Fe, January 18:* A number of business matters were discussed at this session, and H. C. Neuffer reported for the legislative committee. The meeting was then turned over to George Neel, who discussed the technical features of the trial recently held in Carlsbad concerning alleged pollution of the Pecos River by potash wastes. Mr. Neel is manager of the Associated Contractors of New Mexico.

NORTHWESTERN SECTION—*Minneapolis, March 6:* A number of committees were appointed during the business session. The meeting was then turned over to Michael J. Hoffmann, commissioner of highways, who gave an interesting talk on the engineering and financial problems of the Minnesota State Highway Department.

PHILADELPHIA SECTION—*February 18:* This social meeting was acclaimed one of the best parties the Section has ever had. The guests included President Sawyer and Secretary Seabury, and both spoke briefly during the dinner. They were followed by Charles E. Bonine, president of the Engineers Club. Both Francis Friel and Lyle Jenne were honored, as their birthdays come on February 18. The latter acted as master of ceremonies during the "oriental entertainment" that included a magician's performance, songs, and dancing. An outstanding feature of the entertainment was the sound motion pictures shown by Howard H. Demmert, who makes motion picture photography his hobby.

PITTSBURGH SECTION—*January 27* and *February 15:* A symposium entitled "Advances in Materials of Engineering Through Scientific Research" formed the program of the January 27 joint meeting of the Section and the civil engineering section of the Engineers Society of Western Pennsylvania. This theme was presented by L. W. Bass and several of his associates at the Institute, who summarized recent progress in the fields of structural glass, brick-wall construction, thermal insulating materials, plastics, stone, and concrete. The February meeting was also a joint session of the same groups. This gathering was addressed by Samuel O. Dunn, editor of *Railway Age*.

PUERTO RICO SECTION: The Puerto Rico Section announces that its officers for 1939 are Antonio S. Romero, president; Adriano Gonzalez and Antonio Lucchetti, vice-presidents; and Ernesto A. Soler-Lopez, secretary-treasurer.

ROCHESTER SECTION—*February 2:* Alfred G. Forssell, of the Morris Machine Works, Baldwinsville, N. Y., spoke on the subject, "Design and Application of Centrifugal Pumps." In his talk Mr. Forssell showed motion pictures of the model test for the Fort Peck dredge pump taken at the Bonneville laboratory, and also displayed working models of dredge pumps. Collaborating groups were the Rochester Engineering Society and the Rochester section of the American Society of Mechanical Engineers.

SACRAMENTO SECTION—*February 7, 14, 21,* and *28:* The speaker at the first of these luncheon meetings was Emerson Dolliver, whose topic was "Plane Coordinates for Surveys." On the 14th, T. E. Stanton, Jr., Director of the Society, discussed the Annual Meeting and other Society matters of interest. The speakers at the other two gatherings were Clyde Plummer, warden of Folsom Prison, and Harry C. Peterson, curator of Sutter's Fort. The latter described Sacramento's plans for a centennial celebration. He was aided in his presentation by J. B. Maloney and Roy Clair.

ST. LOUIS SECTION—*February 27:* A review of present conditions in Japan and the Philippines was the subject of the talk scheduled for this session. This was given by Stephen M. Pronko, whose extensive residence in the Orient ensured an authoritative lecture.

SAN DIEGO SECTION—*February 23:* After a short talk on national defense the speaker of the evening was introduced. This was Dean Smith, of the Southern California Telephone Company. Mr. Smith gave a graphic description of the research work going on in the Bell Laboratories and presented a talking motion picture depicting the manufacture of insulated copper wire.

TACOMA SECTION—*February 14:* A short reel of colored motion pictures showing the placing of one of the 500-ton concrete anchors for the east caisson of the Tacoma Narrows Bridge was shown with explanatory remarks by Theodore N. Kuss. The rest of the technical meeting consisted of an account of the erection of the Pattulo Bridge over the Fraser River at New Westminister, B. C. This was given by W. G. Swan, Canadian consulting engineer, who showed motion pictures of each phase of the work.

TENNESSEE VALLEY SECTION—*Knoxville Sub-Section, March 7:* The feature of the occasion was a discussion of the professional, economic, and social status of the engineer. Leaders in the enthusiastic discussion were Sherman M. Woodward, N. W. Dougherty, Henry L. Fruend, John F. Pierce, James S. Bowman, George P. Palo, and Ernest A. Bailey. The discussion was based on a questionnaire that had been sent out to the members of the Sub-Section, soliciting their opinions on various phases of the welfare of the profession. The meeting was in charge of Charles W. Okey, chairman of the professional objective committee.

TOLEDO SECTION—*February 22:* Designated "Toledo University Night," this meeting was held for the purpose of cementing further the relationship between the Section and the students and instructors at Toledo University. Following dinner, talks were given by Dr. Clarence Spears and Harold W. Anderson, members of the staff of the university. Later many witnessed the basketball game between the university and the University of Detroit.

VIRGINIA SECTION—*January 4:* About 26 members gathered at the John Marshall Hotel in Richmond for a special dinner in honor of President Riggs. Following dinner Dr. Riggs spoke on the subject of unionism for engineers. His talk was followed by an informal round table discussion.

WISCONSIN SECTION—*Milwaukee, January 25* and *February 24:* Numerous plans for the future were discussed at the January meeting, after which there was an interesting talk on termites. This was given by J. W. Lawrie, research director of the Schlitz Brewing Company, who described methods of extermination. The February meeting was a joint session with the local branch of the American Welding Society. The speakers appearing on this program were Paul Mundie, of Marquette University, and L. C. Bibber, of the Carnegie-Illinois Steel Company.

Student Chapter Notes

OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE—*February 23:* The Chapter was host to the Oklahoma Section and the University of Oklahoma Student Chapter at a dinner meeting at Stillwater. The speaker was Capt. D. A. Morris, who gave an illustrated talk on aerial photography and mapping.

UNIVERSITY OF TEXAS—*January 9:* The Student Chapter at the University of Texas was host at one of its regular meetings to a group of engineers from Houston and engineering students from Rice Institute. This occasion was the result of a new plan on the part of the Student Chapter to invite outstanding engineers of the Southwest to address their group. Thus far the response has been most gratifying. The officers of the Chapter and some of the professors met the group from Houston at the Texas Union where they dined before the regular meeting. The speakers for the evening were Julian Montgomery, state highway engineer, and J. H. Bringhurst, of Houston. Mr. Montgomery discussed the characteristics and abilities that the state expects the young engineer to possess, while Mr. Bringhurst related his experiences in high-order surveying and leveling. A general social hour followed the meeting.

ITEMS OF INTEREST

Engineering Events in Brief

CIVIL ENGINEERING FOR MAY

LATE this spring the Southwest Sewage Treatment Works—largest activated sludge plant in the world—will go into operation in Chicago. In anticipation of this event CIVIL ENGINEERING has scheduled for its May issue an article by William H. Trinkhaus, chief engineer of the Sanitary District of Chicago, describing the plant. "Simplicity, compactness, and economy, from the standpoint of both construction and operation, are the outstanding features in the design of the Southwest Works," says Mr. Trinkhaus. Because of the large area that would have been required for digesting sludge and drying it on sand beds, exhaustive experiments were made by the District, with the result that a mechanical method was originated and perfected for handling sludge by dewatering, drying, and incineration, requiring a very modest area. As another interesting feature, this plant is unique among large-scale works in the use of air lifts in place of pumps for creating the necessary head for returning sludge.

"The Structural Significance of Stress" is the title of Bruce Johnston's contribution to the May issue. "The structural engineer," Professor Johnston writes, "is confronted today with questions involving revision of working stresses, selection of factors of safety, and modification of familiar methods of analysis and design. It is the purpose of this article to correlate some of the factors that are fundamental to a study of these questions." Primary attention is given to the behavior of structural steel members loaded statically; and the interrelation between the following subjects is discussed: (1) stress analyses and the state of stress, (2) yielding of materials and yielding of structures, (3) experimental research and the load history of a structure, and (4) working stresses and the factor of safety in design.

The series of articles on modern construction tools and practice will be continued with a paper whose careful reading should mean many dollars in savings for every engineer in the construction field—regardless of the type of project on which he is engaged. Also on the schedule for the May issue of CIVIL ENGINEERING is the second of F. H. Frankland's two articles on the manufacture of iron and steel, which will describe the production of structural shapes, pipe, plates, and sheets.

One or two remaining papers from the Annual Meeting, and the first group of papers from the Spring Meeting, will round out the issue with material of interest in the fields of highway construction, dam construction, flood control, and city planning.

Winsor Dam, for Boston Water Supply, Honors Late Frank E. Winsor

ENGINEERS have been gratified in recent years to note the growing tendency of public bodies to accord recognition to the profession by naming important structures after the engineers responsible for their creation. A notable instance of such recognition has just been announced. The main structure of the $65,000,000 Quabbin dam project has been renamed "Winsor Dam" by the Metropolitan District Water Supply Commission of Massachusetts. This is in honor of the late Frank E. Winsor, M. Am. Soc. C.E., chief engineer of the Commission, whose sudden death was noted in the March issue.

WINSOR DAM, IN NOVEMBER 1938
General View from Hog Box Trestle, East End

This great project has previously been explained to readers of CIVIL ENGINEERING and so need not be detailed here. In effect, it extends the Boston system westward from the present Wachusett Reservoir by a tunnel about 25 miles long, tapping the Ware River where it crosses the tunnel line. The western terminus is at Quabbin Reservoir, a new storage supply to hold 415,000,000,000 gal. The main structure, now almost completed, is an earth-fill dam 2,640 ft long and 170 ft above the bed of the Swift River. It is this structure that now becomes the Winsor Dam.

In taking its action, the Commission issued a memorial, recalling the outstanding contributions of Mr. Winsor, and mentioning among other things his successful efforts for Government approval of the interstate diversion opposed by Connecticut. The memorial closes with the following tribute:

"From 1932 to the present time Mr. Winsor's sagacity and care in the design of the various structures required and his careful planning and execution of this work were of primary importance in reducing the cost of this work to about $12,000,000 below that originally estimated.

"During the past year the Legislature authorized the Commission to further extend its work by the construction of pressure aqueducts and tunnels to improve the quality and to facilitate the distribution of the water from the sources of supply. That $7,000,000 of federal funds were obtained for this work was due to Mr. Winsor's well-known integrity.

"The forty-seven years of service given to the public by Mr. Winsor and the extensive works constructed under his supervision are a lasting memorial to his vision and industry. To his friends and associates his unlimited kindness and patience, his fidelity to all tasks entrusted to him, and above all his faithfulness to what he conceived to be right constitute his true imperishable memorial."

Roman Roads in England

By T. A. ROSS, M. AM. SOC. C.E.
CONSULTING ENGINEER, LONDON, ENGLAND

THE ACCOMPANYING photograph shows a section of second-century Roman Road recently removed from the western branch of the famous Watling Street, and is now on exhibit in the Science Museum, South Kensington, London. This great road commenced close to where the Tower of London now stands and traversed Britain in a generally western direction, with numerous branches. Watling Street still forms part of the street system of London, under its original name, and the name also appears at intervals where traces of the old highway form part of the modern cross-country road system.

Although the Roman occupation of Britain nominally commenced with the first visit of Julius Caesar and his legions in B.C. 54, conquest actually proceeded in a leisurely manner, and occupation was never secure until roads were built and armed camps formed at points such as road juntions and river crossings which were important from a military point of view.

These points received their Roman name of *castra* or *caester*, meaning a fort or camp. The word still survives in all English towns with names terminating in chester or caster, such as Winchester or

SECOND CENTURY ROAD CONSTRUCTION—A SECTION THROUGH WATLING STREET, HEREFORDSHIRE, FROM AN EXHIBIT IN THE SCIENCE MUSEUM, SOUTH KENSINGTON, LONDON

From the Bottom of the Lowermost Course to the "Surface of Ancient Road" the Thickness Is Approximately 18 In.

Doncaster. In due course this ending crossed the Atlantic to reappear in the United States.

Watling Street eventually reached out to Caerleon, in the border country of Wales, but as occupation of this region was commenced about A.D. 47 the road construction was probably not completed until late in the first century or early in the second century, to which period the section shown may be ascribed.

This section was taken out during reconstruction close to the ancient town of Magnis, now Kenchester in Herefordshire, about 30 miles east of Caerleon. It shows four layers of material, a construction typical of Roman roads, although variations occur sometimes in the thickness and in the materials. It is similar to that described by Vitruvius in his work *De Architectum* and is also found in the Appian Way, which was begun about B.C. 312. The layers of material were named by the Roman builders as follows:

1. *Stratumen*, a foundation layer of gravel, 9.5 in. thick, containing a proportion of limestone, which with the passage of time and the action of moisture has hardened into an approximation to concrete.
2. *Andus*, a layer of large cobbles, 4 in. deep, laid as a flat paving.
3. *Nucleus*, a softer layer of reddish sand, 2 in. thick.
4. *Pavimentum*, a surface paving of small cobbles, 2.5 in. deep.

Thus the total depth of the road was 18 in., as the surface of fine detritus may be ignored. The roadway is 22 ft wide, without curbs or lateral support, but there is a shallow gutter at each side. Instead of being cambered, the surface is flat and slopes slightly to one side, this feature being found also in the other main crossroad through Magnis.

One must remember that these ancient road-builders lived before the age of steel, and preferred to take their material as they found it; hence the common use of water-worn stones of suitable size, derived from river beds, in place of broken stone.

These roads formed an elaborate system, covering thousands of miles, and were created during the whole Roman occupation of Britain between B.C. 55 and A.D. 407. The roads were usually laid out in straight sections aligned from one hilltop to another, and were seldom deflected from their course by natural features, except in very hilly country. They often consisted of a raised causeway of earth or stones, formed from materials found near at hand. Local stone was always used for metaling the surface, and while occasionally a pavement of stone slabs was added, the surface was usually formed of small stones or gravel.

Brief Notes from Here and There

THE New York City Civil Service Commission announces 60 vacancies in the position of Assistant Engineer (Designer), Grade 4, in the Board of Water Supply. Applications, on blanks supplied by the Commission, will be accepted up to April 17. (Written requests for blanks should be addressed to the Commission—Municipal Building, Manhattan—and must be accompanied by a 9-in. self-addressed envelope with 6 cents postage.) Before certification, applicants must have a valid New York State professional engineer's license. They must also be residents of New York State at the time of appointment.

* * * *

"PLANS and Specifications for the Norris Dam" is the title of a comprehensive volume issued by the Tennessee Valley Authority and recently deposited in the Engineering Societies Library. The plans and specifications were compiled after completion of the dam, but in order to facilitate comparisons and for use in future work they have been presented in the same manner as would be required for letting a general contract for the construction. The plans have been corrected in accordance with the actual work performed and the specifications, though written in the future tense, are a description of the methods of construction actually employed. This volume, all in photo-offset, contains 181 pages of text and 134 drawings, 16 by $10^1/_2$ in., and is on sale by the Authority, Knoxville, Tenn., at $2.50 a copy. Another TVA "Technical Monograph" of general interest is "A Technical Review of the Wheeler Project," containing descriptive text, numerous construction photographs, and 31 selected construction drawings. It lists at $1.00 a copy.

* * * *

ESTABLISHMENT of a silver medal award for inventions and discoveries "involving meritorious improvements in the building and allied industries" is announced by the Franklin Institute, Philadelphia. "Building and allied industries" is interpreted to include design and construction of buildings as well as appurtenant equipment. The medal is made possible through a fund provided by the late Frank P. Brown, whose name it bears. Regulations governing the award may be obtained from the secretary of the Committee on Science and the Arts, of the Institute.

* * * *

THE U. S. Bureau of Reclamation is continuing its proposed series of 41 bulletins descriptive of the Boulder Canyon Project. Recent additions to the series include two bulletins bearing the general title "Boulder Canyon Project Final Reports, Part V—Technical Investigations." Bulletin 1 (266 pages) is entitled "Trial Load Method of Analyzing Arch Dams," and Bulletin 2 (184 pages), "Slab Analogy Experiments." The price of Bulletin 1 is $1.50 in paper binding and $2 in cloth, while Bulletin 2 is $1 in paper binding and $1.50 in cloth. Both can be obtained from the offices of the Bureau of Reclamation in either Denver, Colo., or Washington, D.C.

* * * *

ALL THE 870 standards and tentative standards of the American Society for Testing Materials are cataloged by subject in the Index just issued by that organization. Copies of the Index will be supplied without charge on request to A.S.T.M. Headquarters, 260 South Broad Street, Philadelphia, Pa.

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A "COAST-TO-COAST technical program" is the way the Society of Automotive Engineers describes its 1939 World Automotive Engineering Congress. Meetings begin on May 22 in New York, transfer to Indianapolis on May 29, and thence to Detroit on May 31, and the concluding sessions begin in San Francisco on June 6. Members of the American Society of Civil Engineers are invited to attend and participate in the meetings. Program details can be secured from the S.A.E. headquarters, 29 W. 39th Street, New York, N.Y.

NEWS OF ENGINEERS

Personal Items About Society Members

EMIL H. PRAEGER has been named head of the civil engineering department of Rensselaer Polytechnic Institute to succeed PROF. THOMAS R. LAWSON, who will retire at the end of the year after forty years on the staff of the Institute. For the past several years Mr. Praeger has been chief engineer for Madigan-Hyland, of New York City, and as such has been engaged on a number of the major parkway projects in that city.

JOHN C. RIEDEL, deputy chief engineer of the New York City Board of Estimate and Apportionment, has been appointed chief engineer of the board. As such he will sit on the City Planning Commission as a commissioner.

CARL H. PETERSON, JR., formerly instrumentman for the Louisiana State Highway Commission, is now employed in a similar capacity by Ash-Howard-Needles and Tammen on the construction of the Mississippi River Bridge at Greenville, Miss.

K. B. WOODS has accepted the position of assistant professor of highway research at Purdue University. He was previously assistant engineer in the State Highway Testing Laboratory at Ohio State University.

ROBERT C. HAVEN, JR., has been promoted from the position of junior engineer in the U. S. Bureau of Reclamation to that of assistant engineer in the same organization. He is engaged in water-supply investigation on the Green River, Utah, and has his headquarters at Salt Lake City.

P. G. HASELL, until recently assistant state director of malaria control for the U. S. Public Health Service, has accepted the position of associate sanitary engineer for the South Carolina Public Service Authority, with headquarters in Charleston, S.C.

C. O. DOHRENWEND will return to the Armour Institute of Technology as an instructor in civil engineering. Mr. Dohrenwend previously taught at the Institute, leaving his position for doctorate study at the University of Michigan in 1937.

HARRY R. BOLTON, formerly senior engineer for the Metropolitan Water District of Southern California, is now superintendent of the American Concrete and Steel Pipe Company at Natick, Mass.

CLINTON D. HANOVER, JR., has been promoted to the position of chief of the bridge design section of the Bureau of Bridges, New York City Department of Public Works. For the past year he has been engineer in charge of the mechanical and electrical section of the Bureau of Bridges.

WILLIAM J. BARNEY, president of the W. J. Barney Corporation, of New York City, has been elected president of the Metropolitan Builders Association of New York.

BERNARD M. THOMSON, who for the past year has served as acting city engineer of Charleston, S.C., was recently elected city engineer. Mr. Thomson has been in the city service since 1916.

GEORGE H. HENDERSON has been named chief of the Division of Roads and Bridges of the Public Works Department of the State of Rhode Island. This position is analogous to one he held for many years prior to 1935.

E. M. HASTINGS was elected president of the American Railway Engineering Association at the fortieth annual convention of this organization, which was held in Chicago on March 14, 15, and 16. Mr. Hastings, who is chief engineer of the

E. M. HASTINGS

Richmond, Fredericksburg and Potomac Railroad, has been active in the affairs of the Association for more than twenty-five years. He served as director of it from 1932 to 1935 and as vice-president from 1937 to 1939.

HENRY B. SEAMAN, consulting engineer of New York City, was honored by the American Institute of Mining and Metallurgical Engineers at its recent annual dinner, when he became one of the thirteen new members of the "Legion of Honor Class of 1889," who have been members of the Institute for fifty years. Mr. Seaman is also a Life Member of the Society, of which he served as Director from 1900 to 1902.

W. LINDSAY MALCOLM is now director of the school of civil engineering at Cornell University.

GEORGE T. SEABURY, Secretary of the Society, was made a national honorary member of Chi Epsilon, civil engineering honorary fraternity, in a ceremony conducted in Boston on March 18 by the Massachusetts Institute of Technology chapter.

W. W. CALDWELL, vice-president of Iglehart, Caldwell and Scott, Inc., of New York City, is now in Caracas, Venezuela, where he is in charge of the branch office that his firm has recently opened there (at Mercerades a la Gorda, Number 14).

JOHN L. VANDEN BERG is now in the U. S. Department of Agriculture, with headquarters at Friendship, Ark.

JOHN C. NORTON announces the organization of the firm of Heldt and Norton, general contractors of Birmingham, Mich. Mr. Norton was previously structural designer for Smith, Hinchman and Grylls, of Detroit.

BENSON J. WOOD, ARTHUR M. SNIDER, and RALPH K. SEELEY have joined the staff of Shoecraft, Drury and McNamee, and will be located in the Ann Arbor office of this firm.

T. C. FORREST, JR., has withdrawn from the consulting firm of Myers, Noyes, and Forrest, of Dallas, Tex., the firm continuing its practice under the name of Myers and Noyes.

JOHN A. OAKEY is now assistant professor of civil engineering at Villanova College. He was formerly an instructor in the civil engineering department at Columbia University.

THEODORE A. POLANSKY has become connected with the Gulf Concrete and Pipe Company in the capacity of sales manager, and will be located at Houston, Tex. Mr. Polansky formerly held a similar position with the Union Concrete Pipe Company, of Huntington, W.Va.

JOEL C. BEALL is now on the staff of the Colquitt County (Georgia) Health Department, with headquarters at Moultrie, Ga.

ROBERT L. MACDOUGALL, technical adviser to the Atlanta Housing Authority, has been appointed a member of the new Fulton County (Georgia) Planning Commission.

A. C. EVERHAM and A. T. EVERHAM have established a pile-driving and foundation business, with offices in Los Angeles and Kansas City, Mo. For the past twenty years Mr. Everham has been western representative of the Raymond Concrete Pile Company at Kansas City.

FRED SWINEFORD, acting chief engineer of the Ohio State Highway Department's testing laboratory, has been transferred to the bureau of location and design as assistant chief engineer.

CLARENCE M. WESTON is now hydro-electric engineer in the U. S. Engineer Office at Little Rock, Ark. He was formerly senior civil engineer for the Tennessee Valley Authority at Knoxville.

BROWN C. TINEY has resigned as chief engineer of the Calcium Chloride Association in order to become connected with the Michigan Chemical Corporation, of St. Louis, Mich. He will be in charge of the corporation's sales and engineering service of calcium magnesium chloride.

ROBERT LITEHISER has returned to his post as chief engineer of the Ohio State Highway Department's testing laboratory after a year's leave of absence, during which he acted as chief engineer of the Crushed Stone Association, with headquarters at Albany, N.Y.

DOUGLAS CORNELL recently retired as structural engineer of city buildings, Buffalo (N.Y.), Department of Public Works, after forty years in the service of the city.

JOHN W. WOERMANN, principal engineer in the U. S. Engineer Office at Chicago, has retired after being in the federal service since 1890. Mr. Woermann became senior engineer of the Chicago District in 1929 and principal engineer in 1936.

FRANCISCO GASTON, professor of technical English at the School of Engineers and Architects of the University of Havana, has been reelected president of the Cuban Society of Engineers.

P. S. MONK has accepted a position on the staff of the bridge engineer of the South Carolina State Highway Department, with headquarters in Columbia, S.C.

DECEASED

CARMI IRVING BAUSHER (Assoc. M. '98) of Allentown, Pa., died on December 5, 1938, at the age of 66. Mr. Bausher's early experience was with the Phoenix Bridge Company and the Elmira Bridge Company. From 1896 to 1916 he was with the Pennsylvania Steel Company, and from the latter year until 1932 with the Bethlehem Steel Company.

ARTHUR SAMUEL BENT (Affiliate '16) president of the contracting firm, Bent Brothers, Inc., of Los Angeles, Calif., died in that city on February 17, 1939, at the age of 75. Mr. Bent had been active in contracting work on the West Coast since 1886, the important work carried out by his firm including Sweetwater and Gibraltar dams, and numerous waterworks, sewerage, and highway projects in California. He also served as head of a California Chamber of Commerce commission, which drafted a state-wide code of earthquake-resistant construction.

JOHN ALLEYNE CALHOUN BOGART (Assoc. M. '36) assistant civil engineer in the Public Works Department of the U. S. Navy, died at Fernandina, Fla., on March 1, 1939, at the age of 34. Mr. Bogart graduated from the University of Florida in 1931 and, later, was assistant engineer for the Walton County (Florida) Emergency Relief Administration. He also served for a year as city manager of Fernandina, resigning because of poor health.

NOAH CUMMINGS (Assoc. M. '04) who was recently appointed director of the Bureau of Bridges of the New York City Department of Public Works, died suddenly at his home in Mount Vernon, N.Y., on February 13, 1939. He was 65. Except for a period of army service during the Spanish-American War, Mr. Cummings had been in the service of the City of New York continuously since 1894. His principal work during this period was in the Department of Plant and Structures.

RALPH GRAY DAVIS (M. '30) senior engineer for the Beach Erosion Board of the U. S. War Department, Washington, D.C., died there on February 21, 1939, at the age of 50. Mr. Davis spent his entire professional career (since 1911) as an employee of the War Department, except during the World War when he served in the Corps of Engineers, with the rank of lieutenant.

EDWIN LINCOLN GRIMES (M. '04) resident engineer for the J. B. McCrary Engineering Corporation, Atlanta, Ga., died on March 4, 1939, at the age of 75. Much of Mr. Grimes early engineering career was spent in Troy, N.Y., where he was for a time chief engineer of the Bureau of Water Supply. Later he was city engineer and, finally, he established a consulting practice there. About twenty years ago he became connected with the J. B. McCrary Engineering Corporation, serving successively as office engineer, designing engineer, and resident engineer.

FRANCIS DENIS HUBERT LAWLOR (M. '95) superintendent of the Citizens Water Company, Burlington, Iowa, died there on January 25, 1939, at the age of 82. A Canadian by birth, Mr. Lawlor came to the United States in 1880 and entered the employ of the Burlington Railroad, later being transferred to Burlington as first district engineer of the Iowa lines. For several years he was engaged in railroad construction in Montevideo, Uruguay, and upon his return to this country, did surveys for the Burlington and other railroads. In 1903 he accepted the position of superintendent of the Citizens Water Company.

JOHN BERCHMANS MORRISON (Assoc. M. '26) vice-president and sales manager of the Shelt Company, of Elmira, N.Y., died on February 6, 1939, at the age of 39. Mr. Morrison was with the New York State Highway Department from 1921 to 1924. Later he was with the U. S. Bureau of Public Roads, and from 1925 to 1937 he was manager of the Highway Bureau of the Armco Culvert and Flume Manufacturers Association, with headquarters in Middletown, Ohio. In the latter year he became connected with the Shelt Company.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

CHARLES HAROLD OLMSTEAD (M. '36) consulting engineer for the General Tarvia Department of the Barrett Company, of New York City, died in Washington, D.C., on February 1, 1939. Mr. Olmstead, who was 46, served in the U. S. Army during the war, with the rank of second lieutenant. In 1920 he became district engineer at Nashville for the Tennessee State Highway Department, remaining there until 1928, when he joined the staff of the Barrett Company. In 1935 he was appointed consulting engineer for the General Tarvia Department with headquarters in Chicago, and in 1937 was transferred to Washington.

ERNEST GEORGE SCHURIG (M. '16) district engineer for the Procurement Division of the U. S. Treasury Department of Boston, Mass., died on February 12, 1939. Mr. Schurig, who was 65, had been in the Treasury Department in various capacities since 1904. Prior to that he was with the Union Bridge Company (1895 to 1900); the New York Central and Hudson River Railroad (1900 to 1902); and the Bureau of Yards and Docks (1902 to 1904).

RALPH GRAHAM SHANKLAND (M. '19) consulting engineer of Denver, Colo., died in that city on February 6, 1939, at the age of 55. During the war Mr. Shankland saw service as a first lieutenant in the British army, and later was transferred to the A.E.F. He was gassed and severely wounded. For several years following his recovery he was a partner of Ralph J. O'Rourke, consulting engineer, and later became president of Shankland, Ristine, and Company. This firm was active in the construction of many of the important buildings in Denver.

ALFRED FRANCIS THÉARD (M. '15) general superintendent of the Sewerage and Water Board of New Orleans (La.) died in that city on January 2, 1939. Mr. Theard, who was 73, joined the staff of the City of New Orleans in 1893 as a draftsman on topographical surveys. Later he was made office engineer in charge of drainage work, and upon the formation of the New Orleans Sewerage and Water Board in 1903 he kept the same post, becoming first assistant engineer in 1907 and principal assistant engineer in 1914. He held the latter post until 1935, when he was made general superintendent.

FRIEND PITTS WILLIAMS (M. '09) recently retired secretary engineer of the Water Power and Control Commission of the State of New York, died in Albany, N.Y., on February 20, 1939. Mr. Williams was resident engineer for the Pittsburgh, Shawmut, and Northern Railroad from 1899 to 1905, and from the latter year until 1920 he was assistant and special deputy state engineer (New York State). He then became secretary engineer of the Water Power and Control Commission.

ROBERT WALTER WOOD (M. '36) of West New Brighton, N.Y., died at Fort Myers Beach, Fla., on February 3, 1939, at the age of 58. Mr. Wood spent practically his entire career in the service of the Borough of Richmond (New York City), joining its engineering bureau in 1904. For a number of years he was engineer in charge of field work. He retired in 1937.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From February 10 to March 9, 1939, Inclusive

Admissions to Membership

Ackerson, Duane, Wright (Jun. '38), Route 12, Box 632, Milwaukie, Ore.

Adams, George Barton (Jun. '38), 800 Ennis Ave., Bryan, Tex.

Ali, Raymond Nicholas (Jun. '38), Junior Engr. (Civ.), U. S. Engr. Dept., Chamber of Commerce Bldg. (Res., 4321 Graphic St.), Pittsburgh, Pa.

Atkinson, Harry Walter (Jun. '38), 28 West Logan St., Harrisburg, Ill.

Baker, George Milford (Jun. '39), 304 Gayley St., Media, Pa.

Bakken, Thorvald Englund (Jun. '38), Trackman, N.P. Ry., Glen Ullin, N.Dak.

Barnes, Ted Collings (Jun. '39), Surv., Magnolia Petroleum Co., Box 900, Dallas, Tex.

Bauders, Meldon Leo (Assoc. M. '39), Associate Highway Engr., State Div. of Highways, 801 California State Bldg., Los Angeles (Res., 619 Alhambra Rd., San Gabriel), Calif.

Behling, Wesley A. (Jun. '39), Junior Engr., Bureau of Reclamation, Knight Blk., Provo, Utah.

Bell, Aubrey Blan (Jun. '38), Asst. to H. L. Thackwell, 209 East Cotton St., Longview, Tex.

Biggs, Edwin Forrest (Assoc. M. '39), Production Mgr. Design Dept., TVA, 314 Union Bldg., Knoxville, Tenn.

Bischoff, Dean Edward (Jun. '38), 2560 Orchard Ave., Ogden, Utah.

Blattner, Sanford David (Jun. '39), Care, Magnolia Petroleum Co., Box 48, Navasota, Tex.

Bluestone, Enoch (Jun. '39), Junior Engr., Weinberger & Rodd, 701 Seventh Ave. (Res., 116 Henwood Pl.), New York, N. Y.

Brenneman, John William (Assoc. M. '39), Asst. Prof., Mechanics and Materials of Constr., Pennsylvania State Coll., 202 Eng. Bldg. A, Pennsylvania State Coll., State College, Pa.

Brodrick, Gordon Horth (Jun. '38), Transitman, U. S. Bureau of Reclamation, Box 171, Cody, Wyo.

Burleigh, Harry Paul (Assoc. M. '39), Hydr. Engr., Bureau of Agri. Economics, Masonic Bldg. (Res., Palo Duro Apartments), Amarillo, Tex.

Carter, Lauren Deane (Jun. '38), 1012 West 6th St., Little Rock, Ark.

Cefola, Anselm (Assoc. M. '39), Instr. in Drafting, Coll. of the City of New York, 139th St. and Amsterdam Ave., New York, N.Y.

Chapman, George Edward (Jun. '38), Junior Engr., State Highway Comm., Masonic Temple, Topeka, Kans.

Chudoba, Albert Lawrence (Jun. '39), Topographical Draftsman, with Boro Pres. of Manhattan, Municipal Bldg., New York (Res., 6011 Woodbine St., Brooklyn), N.Y.

Clark, Marion Jay (June. '39), Designer, Bridge Dept., State Road Comm., Room 419, State Capitol, Salt Lake City, Utah.

Clay, Lucius DuBignon (M. '39), Capt., Corps of Engrs., U. S. Engr. Office, Denison, Tex.

Coleman, Paul Henderson (Jun. '38), Rodman, State Highway Dept., Box 472, Commerce, Tex.

Collier, Samuel Meyer (Assoc. M. '39), Asst. Engr., Board of Water Supply, 346 Broadway, New York, N.Y.

Cotterman, Robert Lee (Jun. '39), Rodman and Draftsman, Montgomery County Engr's. Office, County Court House (Res., 128 Indianola Ave.), Dayton, Ohio.

Cowin, Alden Lloyd (Assoc. M. '39), Office Engr., Hetch Hetchy Water Supply, City and County of San Francisco, 428 Birch St., Redwood City, Calif.

Cravens, James Wade (Jun. '39), Dist. Office Engr., Dist. 1, State Highway Dept., Box 468, Paris, Tex.

Curington, Henry Wisdom (Jun. '38), Junior Office Engr., State Highway Dept. (Res., 501 Navasota St.), Groesbeck, Tex.

Curtis, Earl Howard (Assoc. M. '38), Hydr. Engr., U. S. Geological Survey, 404 Engr. Experiment Station, Ohio State Univ., Columbus, Ohio.

Denmark, Marion Alexander (Jun. '38), Draftsman, Wharton County, County Court House, Wharton, Tex.

Denton, Charles Edward (Jun. '38), 327 Main St., Carthage, Ill.

Dickman, W. Bernard (Jun. '39), Civ. Eng. Insp., Public Utilities Comm., City and County of San Francisco (Res., 3775 Fillmore), San Francisco, Calif.

Donnan, William Charles (M. '39), Div. Supt., Distrib., Bureau of Water, City of Pittsburgh, 412 City-County Bldg., Pittsburgh, Pa.

Dopp, Robert Henry (Jun. '39), Box 12, Key West, Fla.

Duder, John Schmalz (Jun. '39), Junior Engr., Mountain Fuel Supply Co., 36 South State (Res., 117 L St.), Salt Lake City, Utah.

Edwards, Gail Phillips (M. '39), Prin. San. Chemist, Wards Island Sewage Treatment Plant, Dept. of Public Works, City of New York, Wards Island, New York (Res., 736 Burns St., Forest Hills), N.Y.

Eldridge, Albert Matthews (Jun. '38), County San. Engr., Bartow County Health Dept., Box 71, Cartersville, Ga.

Epperson, LeRoi R. (Assoc. M. '38), Senior Res. Engr., State Highway Board of Georgia, East Point (Res., 981 Katherwood Drive, S.W., Atlanta), Ga.

Fabian, Edward Sydney (Assoc. M. '39), Asst. Prof., Civ. Eng., Univ. of Tennessee, Carrick Hall, Univ. of Tennessee, Knoxville, Tenn.

Foster, Charles Bradford, Jr. (Jun. '38), Box 914, Memphis, Tex.

Fox, Jeff Stanley (Jun. '39), Instrumentman, State Highway Dept., 106½ South Anglin St. (Res., 734 North Main St.), Cleburne, Tex.

Fowler, Randall Boone (Assoc. M. '39), State Director of Operations, WPA of Louisiana, 804 Canal Bank Bldg., New Orleans, La.

Fuller, Edward Harmon (Jun. '38), Graduate Fellow, Dept. of Civ. Eng., Virginia Polytechnic Inst. (Res., University Club), Blacksburg, Va.

Galligan, William Bartholomew (Jun. '38), 1749 Grand Concourse, New York, N.Y.

Graham, Doyle Elijah (Jun. '38), 212 Main St., Rapid City, S.Dak.

Greulich, Gerald Gregory (Assoc. M. '39), Sales Representative, Specialty Sales Div., Carnegie-Illinois Steel Corporation, Carnegie-Illinois Bldg. (Res., 778 Osage Rd., Mt. Lebanon), Pittsburgh, Pa.

Griffis, LeVan (Jun. '38), 1002 East California St., Pasadena, Calif.

TOTAL MEMBERSHIP AS OF MARCH 9, 1939	
Members	5,635
Associate Members	6,333
Corporate Members	11,968
Honorary Members	27
Juniors	3,947
Affiliates	73
Fellows	1
Total	16,016

Guillard, Eugene (Jun. '38), Asst. Engr., Kinsey Eng. Co., 512 Court St. (Res., 1123 Highland Ave.), Pekin, Ill.

Hall, John Fenwick (Jun. '39), Asst. City Engr., Box 432, Junction City, Kans.

Hancock, James Harvey (Jun. '39), Detailer, Mississippi Steel & Iron Co., Box 54 (Res., 620 Yazoo), Jackson, Miss.

Harris, Glen Hugh (Jun. '38), 723 East Harris Ave., San Angelo, Tex.

Harris, Robert Otis (Assoc. M. '39), Asst. Div. Engr., State Highway Dept., Montgomery (Res., 306 Michigan Ave., Mobile), Ala.

Harris, Robert Ray (Assoc. M. '39), Asst. Engr., State Dept. of Health, 620 South 3d St. (Res., 127 North 44th St.), Louisville, Ky.

Harrison, Evelyn (Jun. '39), Cartographic Draftsman, U. S. Geological Survey, Dept. of Interior (Res., 1906 N St., N.W., Apartment 22), Washington, D.C.

Hightower, Charles Lee, Jr. (Jun. '38), Bridge Draftsman, State Highway Dept., State Office Bldg. (Res., 1320 Senate St.), Columbia, S.C.

Hoglin, Harold Alvin (Jun. '38), 531 Arapahoe Ave., Boulder, Colo.

Howard, Earl Rockwell (Jun. '38), Asst. Engr., Met. Dist. Sewage Treatment Plant, City of Hartford, Eng. Dept., City Engr. Office (Res., 816 Wethersfield Ave.), Hartford, Conn.

Huntley, Wayne Eastwood (Jun. '39), Eng. Aide, U. S. Dept. of Agriculture, AAA Branch, Savings Bank Bldg., Ithaca, N.Y.

Hurst, Harold Elvin (Jun. '39), Rodman, C.M. St. P. & P.R.R., Miles City, Mont.

Hyden, Bailey Sylvanius (Jun. '38), Instrumentman, State Highway Dept., 512½ Vincent St., Houston, Tex.

Johnson, Charles Franklin (Assoc. M. '39), Senior Engr., Commrs. of Sewerage of Louisville, 400 M. E. Taylor Bldg. (Res., 206 Pennsylvania Ave.), Louisville, Ky.

Johnson, Charles Vernon (Jun. '38), Subinspector, U. S. Engrs., Memphis, Tenn. (Res., 711 Kinzer St., Poplar Bluff, Mo.).

Jumper, Harry Drake (Assoc. M. '39), Engr., Consolidated Rock Products Co., 2730 South Alameda St., Los Angeles, Calif.

Kimmel, Raymond Malcolm (Jun. '39), Engr., The Texas Co. (Res., 1300 Ninth St.), Port Arthur, Tex.

Kruchkow, Norman (Jun. '38), Junior Topographic Engr., U. S. Geological Survey, Box 268, Mobile, Ala.

Kuenning, Walter Henry (Jun. '39), With the Standard Oil Co. (Ohio), Solar Refinery, Lima, Ohio.

Kuentz, Carl Lee (Jun. '38), Rodman, State Highway Dept., Box 742, Commerce, Tex.

Lacy, Edward Randolph (Jun. '38), Asst. Eng. Aide, Maps and Survey Div., TVA, 705 Pound Bldg. (Res., 509 Walnut St.), Chattanooga, Tenn.

Lamp, Donald George (Jun. '38), Project Engr., WPA, 1668 Twenty-seventh Ave., Columbus, Nebr.

Land, James Love (M. '39), Materials Engr., State Highway Dept. (Res., 101 Mulberry St.), Montgomery, Ala.

Larsen, Herluf Thomsen (Jun. '39), Draftsman, Dept. of Subways and Traction, 20 North Wacker Drive (Res., 6415 Drexel Ave.), Chicago, Ill.

Larssen, George Edward (Jun. '39), Insp., State Highway Comm., Box 545, Davenport, Iowa. (Res., 917 Grant St., Beatrice, Nebr.)

LaRue, George Edgar (Jun. '38), Rodman Eng. Dept., C.M.St.P. & P.R.R., Care, Div. Engr. (Res., 34 Fourth St.), Savanna, Ill.

Lauer, Willard Wood (Assoc. M. '39), Supt., The H. K. Ferguson Co., Hanna Bldg., Cleveland (Res., Doan Ave., R. D. 1, Painesville), Ohio.